SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

JUNE 1898.

GENERAL PHYSICS.

602. *Hardness of Metals.* **A. Föppl.** (Annal. Phys. Chem. 63. 1. pp. 103–108, 1897.)—In these experiments two test specimens of each material are polished to a cylindrical surface 20 mm. radius, then laid crosswise and pressed together in the testing machine. It is found that for each material the surface of indentation is proportional to the pressure applied, and that therefore the specific pressure is a measure of the hardness. The numerical value of the hardness, h, is dependent on the radius of the cylindrical surfaces; the product $h\sqrt[3]{r}$ being constant. A. S.

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603. *Elastic Coefficient of Platinum.* **A. Winkelmann.** (Annal. Phys. Chem. 63. 1. pp. 117–123, 1897.)—The elastic coefficient is measured by observing the deflection of a loaded bar. The object of the work is not so much the exact determination of the coefficient as its variation with time and changes of temperature. Repeated heatings to 400° C. increase the value of the coefficient at 20° C.; with efflux of time, the bar remaining at 20°, the coefficient diminishes. In the experiments recorded the original value at 20° was 16,926; after many heatings to 400° its value was 18,380; at the end of about 10 months' rest the value was 17,516; after an additional rest of about 3½ months (13½ months in all) the value was 17,508. Whether the coefficient would have attained its original value if left undisturbed for a longer period is not known. A. Gs.

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604. *Compressibility of Salt-Solutions.* **H. Gilbault.** (Zeitschr. phys. Chem. 24. pp. 385–440, 1897.)—The determinations at low

temperatures are made by the method of Cailletet, the only modification being the employment of a gilded platinum wire to show the height to which the mercury has risen in the piezometer-tube, instead of gilding the tube itself. At higher temperatures the liquids are compressed in a thick-walled glass tube, the part containing the liquid being heated in a glycerine-bath. Solutions of benzoic acid and borneol in ether and of resorcinol in alcohol are examined. Complete isotherms for a number of temperatures up to the critical point are determined, and from them the critical data obtained. The critical temperature of the solutions is taken to be the temperature at which the volume, u, of the solution when wholly liquid and under the pressure of its saturated vapour becomes equal to the volume, u', which it possesses when the whole of the solvent has just evaporated. The critical temperatures and pressures of the solutions are higher than those of the pure solvents, the values increasing at first very rapidly with concentration. When the concentration is measured by the ratio between the number of dissolved molecules and the total number of molecules in the solution (the molecular weight of the salt being assumed to be half that represented by its formula), the rise of critical temperature and pressure with concentration is independent of the nature of the dissolved substance.

The value of $1/u+1/u'$ is a linear function of the temperature, just as in the case of pure substances.

Neither the formula of van der Waals nor that of Clausius represents the connection between volume and pressure at constant temperature with sufficient accuracy. The empirical formula

$$v = -1/\mathrm{M}\,k \log(p-\mathrm{A})+\mathrm{B}p+\mathrm{C}$$

—where v, p, and M are the volume of that quantity of substance which possesses unit volume at 0° and atmospheric pressure, the pressure, and the modulus of common logarithms, and A, B, C and k are constants—represents the results obtained with great accuracy even near the critical temperature and at 200 atmospheres. From this formula the mean and true coefficients of compressibility, $-(v-v_1)/(p-p_1)$ and $-dv/dp$, are easily calculated.

The influence of temperature on the compressibility is represented by the formula

$$-dv/dp = a-b\,p/\pi \Big/ \frac{\theta-t}{273+t} + d\,\frac{p-\pi}{\pi},$$

where a, b, and d are constants, and π and θ are the critical temperature and pressure. The constants a, b, and d have the same values for the solvent and solutions in it; from which it follows that at corresponding temperatures and pressures the solutions and solvent have the same compressibility. Since, as above mentioned, solutions in the same solvent and of equal molecular concentration have the same critical temperature and pressure, such solutions also have the same compressibility at corresponding temperatures and pressures.

The influence of concentration on compressibility is more fully investigated for aqueous solutions. The mean compressibility between 1 and 300 atmos. at 20° is used; and in order to have comparable numbers the molecular compressibility, μ, is calculated for volumes containing equal numbers of molecules. The molecular concentration is calculated in the same way as before. The formula

$$\frac{\log\mu-\log\mu_0}{a}\frac{d'}{d}=k$$

is found to represent the relation between molecular compressibility and concentration with great accuracy. In it μ and μ_0 are the molecular compressibilities, d and d' the densities of the solution (of concentration a) and of the solvent, whilst k is a constant. Solutions of 18 salts in water are examined, and give results which are very completely represented by the above equation. The values of k are closely connected with the contraction which takes place when 1 gram of the salt is dissolved so as to form an infinitely dilute solution. Calling this σ, the following equation holds good for all the salts examined:

$$\sigma=1{\cdot}7067\,(k-0{\cdot}48)+0{\cdot}15024\,(k-0{\cdot}48)^2.$$

The same equation applies to a solution of cadmium iodide in alcohol, so that its application would appear not to be limited to water. T. E.

605. *Electrical Theory of Universe.* (Elect. Rev. 42. pp. 72–74, 138–141, 283–284, 1898.)—This is a somewhat disconnected collection of facts and phenomena which are stated to support the idea of an electrical origin for the various celestial phenomena, and also for the meteorological phenomena of the atmospheres of the earth and planets. C. P. B.

606. *Slide-Rule for Barometric Corrections.* **B. Sresnewsky.** (Zeitschr. Instrumentenk. 17. pp. 335–338, 1897.)—This instrument is designed for applying various corrections to barometric readings, so as to reduce them to sea-level, standard temperature, and normal hygrometric state, according to the formula of Rühlmann (see Wild's 'Repertorium für Meteorologie,' vol. 10). In order to make these calculations by slide-rule, the formula is somewhat simplified; but the author shows that the simplification does not introduce serious errors. A drawing of the instrument is given. R. A.

607. *States of Equilibrium.* **F. Wald.** (Zeitschr. Phys. Chem. 24. pp. 509–512, 1897.)—Ostwald has concluded that, when a system leaves one state of equilibrium for another, it is not

the stablest possible that is assumed, but the nearest that is more stable. The author shows that Ostwald's theoretical explanation of this "law" is untenable, and he gives reasons for viewing it only as a "rule," the operation of which is dependent on external circumstances. R. E. B.

608. *Motion of Liquids.* **M. E. Fontaneau.** (Comptes Rendus, 126. pp. 630–631, 1898.)—M. Fontaneau here states that by a simple transformation of the ordinary equations of hydrodynamics he has shown the existence of a function Π, defined by

$$Lp + Mq + Nr = \Pi,$$

where $p\ q\ r$ are components of stream-velocity, and L M N components of rotation; and he proposes to integrate that equation for the case in which $\Pi = 0$, or the axis of rotation is at right angles to the stream-lines, and he proposes to employ curvilinear biorthogonal coordinates. The analysis is not given in this note. S. H. B.

609. *Irreversible Processes.* **Anton Wassmuth.** (Annal. Phys. Chem. 62. 3. pp. 522–527, 1897.)—The energy of a system is in this paper denoted by

$$L = \tfrac{1}{2}\Sigma a_{\mu\nu}\dot{p}_\mu\dot{p}_\nu,$$

where $p_\mu\ p_\nu$ are generalised coordinates, and the coefficients "a" are functions of them or constants.

The potential is V; so that

$$\Sigma P_i \partial p_i = -\partial V,$$

P_i being a component of force.

$$F = \tfrac{1}{2}\Sigma b_{\mu\nu}\dot{p}_\mu\dot{p}_\nu$$

is the dissipation-function. Then the μth Lagrange equation gives

$$Q_\mu = \frac{d}{dt}(a_{\mu_1}\dot{p}_1 + a_{\mu_2}\dot{p}_2 + \&c.) - P_\mu$$
$$+ (b_{\mu_1}\dot{p}_1 + b_{\mu_2}\dot{p}_2 + \&c.) = 0.$$

It follows, by the correspondence of dimensions, that

$$a_{\mu_1} = \tau_{\mu_1} b_{\mu_1}\ \&c.,$$

where τ is the *time of relaxation*; and so

$$\frac{dL}{dt} = \Sigma\tau_{\mu\nu}\frac{dF_{\mu\nu}}{dt} \quad \text{and} \quad \Sigma\tau_{\mu\nu}\frac{dF_{\mu\nu}}{dt} + \frac{dV}{dt} = -2F,$$

and if there be no forces derived from the potential V,

$$\frac{dL}{dt} = \Sigma r_{\mu\nu} \frac{dF_{\mu\nu}}{dt} = -2F. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (II.)$$

This is, in effect, the same equation as obtained by Natanson (Zeitschrift für Phys. und Chemie, 21. pp. 183–217, 1896).

Herr Wassmuth gives an example:—

The energy per unit of volume in ether shall be assumed to be

$$L = \frac{K}{8\pi}(P^2 + Q^2 + R^2),$$

where P Q R are three mutually perpendicular vectors, and may be

$$P = \dot{p}_1, \quad Q = \dot{p}_2, \quad R = p_3,$$

the time-differentials of three independent generalised coordinates p_1, p_2, p_3.

The potential per unit of volume shall be

$$V = \frac{\mu}{8\pi}(\alpha^2 + \beta^2 + \gamma^2),$$

where α, β, γ are connected with P, Q, R by the cyclic relations

$$\mu \frac{d\alpha}{dt} = \frac{dR}{dy} - \frac{dQ}{dz} \quad \&c.$$

Also it is assumed that initially we had

$$\alpha = \beta = \gamma = 0.$$

From these data, by the use of the Maxwell-Helmholtz principle of continuity, are derived the cyclic relations

$$K \frac{dP}{dt} = \frac{d\beta}{dz} - \frac{d\gamma}{dy} \quad \&c.$$

If there be resistance, we have

$$F = \tfrac{1}{2}C(P^2 + Q^2 + R^2),$$

C being a constant; and hence, if V be constant, follows

$$\frac{dL}{dt} = -2F, \quad . \quad \text{as in (II.)}.$$

S. H. B.

LIGHT.

610. *Elastic Bodies and Light.* **P. Glan.** (Annal. Phys. Chem. 63. 1. pp. 230–233, 1897.)—This is a continuation of previous mathematical investigations respecting the relations between the elastic properties of bodies and their behaviour to heat- and light-waves. The present paper deals with the absorption-coefficient of a substance for light-waves and its conductivity for heat and electricity. J. L. H.

611. *Spectroscopy.* **M. Hamy.** (Comptes Rendus, 125. pp. 1092–1094, 1897.)—The author describes an apparatus, founded on the principle of interference, for separating radiations which differ but little in wave-length. J. J. S.

612. *Star Spectra with Grating.* **C. F. Poor** and **S. A. Milchell.** (Ast. Phys. Journ. 7. pp. 157–162, 1898.)—This paper gives the results of the first really successful photographs of stellar spectra which have been obtained up to the present by the use of a concave grating. In 1892 Crew, at the Lick Observatory, obtained a few spectra by using the grating in connection with an objective, the whole forming a telespectroscope. The present authors use the grating direct, the light being focussed directly by reflection from the concave surface onto the photographic plate. For the experiments described, a small grating with a ruled surface of 1 × 2 inches was used. This had a radius of curvature of one metre, and had 15,000 lines to the inch. The whole was mounted in a light box strapped to the side of a clock-driven telescope which acted as finder, and the grating so adjusted that the length of the lines were parallel to the equator, this being the most accurate position, as any slight inaccuracy of the driving of the clock will only lengthen the spectral lines and not broaden or blur them. Sirius was the star used at first, and exposures were given ranging from ten minutes to one hour, using the first-order spectrum and Seed's gilt-edge plates. The resulting spectra are 5 cm. long, and vary in width from 0·1 m. to 1·5 mm.

Two plates are given, illustrating the spectra obtained, and these show the best of definition. C. P. B.

613. *Theory of Diffraction.* **G. Sagnac.** (Journ. de Physique, 7. pp. 28–36, 1898.)—The author treats, by geometrical construction, the case of diffraction of plane waves by a screen pierced with parallel slits. Finally the classical formula is reached, which is established analytically by the aid of integrations and by taking the sum of a series of sines or cosines

of arcs in arithmetical progression. The geometrical method, which furnishes a simple demonstration, gives besides directly the solution of all the fundamental questions relative to diffracted beams. J. J. S.

614. *Lens Formulæ.* **R. Steinheil.** (Zeitschr. Instrumentenk. 17. pp. 338–344, 1897.)—As an example of the application of the lens formulæ of Charlier, the author calculates the radii of a doublet, being given the constants of the glass and the optical conditions to be fulfilled. To check the truth of the formulæ, the particular case is considered of the object-glass of the heliometer at Königsberg, (1) for yellow light, (2) for violet light. The formulæ neglect the thickness of the lenses; consequently the results are only approximate: they do not compare very well with those calculated by the trigonometrical method of A. Steinheil. R. A.

615. *Argon in Röntgen-Ray Tubes.* **H. L. Callendar** and **N. N. Evans.** (Electrician, 40. pp. 394–395, 1898.)—A continuation of experiments made in 1896, using tubes of various types under varied conditions with a very intense current and high vacua. Elaborate details are given, and it is deduced that:—(1) the hydrogen occluded in the kathode plays the part of a carrier of the discharge from the metal to the gas; (2) with sufficient occluded hydrogen, there is little or no sputtering of the aluminium; (3) in absence of hydrogen, the discharge is conveyed by particles of the metal itself, which excite fluorescence and generate Röntgen rays wherever they impinge; (4) in default of extraordinary precautions for drying, and removal of hydrogen from the electrodes, the residual gas is in most cases hydrogen or water-vapour.

Similar experiments are recorded with dry air, hydrogen, oxygen, and water. Hydrogen seemed the most suitable gas for *x*-ray tubes; but "helium, being also a very light gas, might be equally good."

If the great resistance to the passage of the discharge in the case of argon be due to its monatomic character, it might be expected that mercury vapour would behave in a similar manner. Experiments with inverted U-tubes in which mercury was distilled and exhausted, showed that a very small trace of another gas enormously reduced the resistance; so that, if the vapour could be obtained quite pure, it might not conduct at all. The presence of argon by itself had little, if any, effect on the production of Röntgen rays, since the amount present in the tube could be varied within wide limits.

Another series of experiments, not yet concluded, investigated the apparent absorption of argon. It was observed that a very good vacuum could be obtained by finally absorbing residual water-vapour by phosphoric anhydride. When dry argon was then admitted to a pressure of 0·160 mm., the tube was filled with blue light and gave the argon spectrum without hydrogen or nitrogen. After half an hour of a direct or alternating current the tube became very black, but there was no change in the pressure. S. G. R.

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616. *Röntgen Rays.* **A. Volta.** (Elettricità, Milan, 17. pp. 84-87, 1898.)—This is a note on Prof. Filippo Re's pamphlet ('La teoria dei raggi Roentgen,' Palermo, Reber, 1898), in which, after discussing the various theories of the nature of Röntgen radiation, Prof. Re arrives at the conclusion that the Röntgen rays consist of electric waves of infinite wave-length, or practically so. This explains the great diffusivity, the absence of interference phenomena, the luminescence, the passage round obstacles, the manner of reflexion, the absence of refraction, the photographic action. The theory admits the possibility of polarisation, but is weak in regard to the differences between different Röntgen radiations in respect of their penetrative powers. A. D.

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617. *Röntgen Rays.* **G. Adam.** (Elect. Rev. N.Y. 32. pp. 148-149, 1898.)—The author suggests that the molecules driven from the kathode lose their charge and are broken up into atoms at the surface bombarded, and that this is sufficient to account for the conversion of kathode rays into Röntgen rays. A. D.

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618. *Law of Emissivity.* **C. E. Guillaume.** (Ind. Élect. 7. p. 69, 1898.)—This is a note on Lummer and Pringsheim's result that Stefan's law of the total radiation varying as the fourth power of the absolute temperature, though at first founded on a narrow range of temperatures, holds good for dead-black radiators from 100° to 1300° C.; the results being more exactly expressed by saying that it varies as the 3·96th power. A. D.

HEAT.

619. *Expansion of Water between* 0° *and* 40°. **P. Chappuis.** (Annal. Phys. Chem. 63. 1. pp. 202–208, 1897.)—A dilatometer, made of *iridium-platinum*, and consisting of a cylindrical tube 110 cm. long and 38 mm. diameter, is employed. The values obtained for the densities only differ by one or two units in the sixth decimal place from those obtained by the same author in 1892, when he employed a *glass* vessel as his dilatometer. A. Gs.

620. *Comparison of Heat Conductivities.* **W. Voigt.** (Annal. Phys. Chem. 64. 1. pp. 95–100, 1898.)—This is an addition to a previous paper (see Phys. Soc. Abstracts, No. 125, 1897), in which the author explained a new method for determining the relative heat conductivities along the principal axes of a crystal. The method is now applied to determinations of the relative conductivities of two solid bodies. Thin plates are cut, one of each substance, in the shape of right-angled triangles; the plates are cemented with their hypotenuses so as to form a rectangle. The combined plate is coated with a very thin layer of elaïdic acid to which wax and turpentine are added. In such mixtures the acid melts at about 45° C., and solidifies again in tiny crystals, yielding a well-defined isothermal curve. The ratio of the two sides of the triangles is that of the two conductivities to be determined, as fixed approximately by a preliminary experiment. The heating is effected by means of a copper bar at 70° or 90° C., either the short side of the better heat-conductor, or the long side of the poorer conductor being placed against the copper bar. The conductivities are derived from measurements of the angles under which the isothermals cross the common hypotenuse. These angles can be measured within fractions of a degree; a mistake of $\frac{1}{4}$° would cause an error of 2 per cent. in the heat conductivities. Some particulars are given of experiments with three glasses. H. B.

621. *Thermometer-Testing at the Reichsanstalt.* **F. Kohlrausch.** (Zeitschr. Instrumentenk. 18. pp. 76–85, 1898.)—This is a publication of the official regulations under which thermometers are tested and certified at the Reichsanstalt, and also at the branch institution at Ilmenau which is under the control of the Reichsanstalt. The thermometers are distinguished as normal, laboratory, meteorological, clinical, industrial, and domestic thermometers. The Reichsanstalt alone deals with normal instruments; it does not test thermometers for domestic use; other thermometers may be offered at either place. The standard scale for normal thermometers is the hydrogen-thermometer scale of the Bureau International of 1887; for standardising calibrations above 100° C., air-thermometers are used. The paper states the conditions which must be satisfied in order to obtain certificates in the various classes, and also the terms. Thermometers approved are marked

with the German eagle and the letters P.T.R. or G.S. (Ilmenau), and also with a number. H. B.

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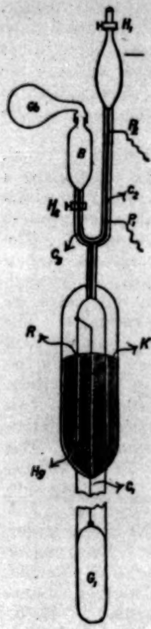
622. *Thermostat.* **C. Richter.** (Elektrochem. Zeitschr. 4. pp. 155–156, 1897.)—The inventor claims the advantages of portability, cheapness, and accuracy, and by means of the apparatus the required temperature may be maintained to within 0°·1 C. To set the instrument, the bulb G_1 is immersed in the liquid the temperature of which is to be kept constant, while the stopcock at H_1 is open and that at H_2 closed. The air in G_1 expands and forces the mercury in K through the capillary tube C_2 into the chamber E. As soon as a state of equilibrium is reached at the required temperature, the stopcock at H_1 is closed and that at H_2 cautiously opened. The mercury is thus allowed to flow from E into B until the extremity of the thread in C_2 nearly touches the platinum wire P_2. If too much mercury be accidentally run down, the level may be restored by pressing the indiarubber ball G_b. The stopcock H_2 is now closed and the apparatus is ready for use. Should the temperature rise too high, the thread of mercury P_1P_2 completes the circuit of an electrical arrangement by which the gas-supply is cut off, and only a small bye-pass remains lighted. If, on the other hand, the temperature falls, the mercury descends below P_2, the circuit is broken, and the cock of the burner opened by a spring. J. W.



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623. *Specific Heat of Refractory Metals.* **H. Mache.** (Wien. Akad. Sitzber. 106. pp. 590–593, 1897.)—The specific heat of the more refractory metals has up till now only been determined in the state of powder, owing to the difficulties of obtaining them in any other form. Moissan has, however, succeeded in obtaining some of these in more compact form by means of his high-temperature furnace, and the author has now determined the specific heat of those so obtained. These are vanadium, wolfram, uranium, chromium, and palladium. Bunsen's calorimeter was used, and the different determinations made with each metal agree to two per cent. The mean values of the specific heats are: Pd. 0·0549, Cr. 0·1208, V. 0·1153, Wo. 0·0336. The values found for uranium were 0·0571 and 0·0569, but the specimens were found to contain impurities. The atomic heats which these values give are, Pd. 5·83, Cr. 6·34, V. 5·9, Wo. 6·17. J. B. H.

624. *Specific Heat of Steam at Constant Pressure.* **O. Tumlirz.** (Wien. Akad. Sitzber. 106. pp. 654–667, 1897.)—The author calculates the specific heat of steam at constant pressure from the results of experiments performed in 1866 by Hirn and Cazin on the expansion of superheated steam. The thermodynamics of the question is given in full, and the use of Hirn and Cazin's results for deducing the specific heat is also justified. The results show that the specific heat of steam at constant pressure has, from the saturation-point to that adiabatic which meets the saturation-curve in the point $\theta=100°$ C., $p=1$ atmosphere, for every pressure the same mean value. This constant value is 0·5256.

J. B. H.

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625. *Equilibrium of Three-Component Solutions.* **B. Kuriloff.** (Zeitschr. phys. Chem. 24. pp. 441–467, 1897.)—The two special difficulties that beset this study, viz., the usually high fusing-points of some of the components and the simultaneous occurrence of many solid phases, are absent from the system picric acid, β-naphthol, and benzol, in which the solubility-curves show that only binary solid phases, benzol picrate, and β-naphthol picrate, occur in addition to the components themselves. Denoting these five substances, one or more of which, as solid phases, may with the solution and vapour constitute the system in equilibrium, by P, N, B, BP, NP respectively and plotting the isothermals for 135°, 120°, 100°, 29°·5 on a triangular diagram after Roozeboom's manner, the author obtains the following results. For temperatures between 157° (the fusing-point of NP) and 116° the isothermals are continuous curves beginning and ending on the PN-axis, and NP is the only solid phase present except at 116°, when there is no B in the system, in which case N too is present; this condition corresponds to some point *q* towards the N-end of the PN-axis. From 116° to 111° the isothermals are made up of a stretch *er* starting on the PN-axis with NP as sole solid phase, and a stretch *rs* ending on the BN-axis with N as solid phase, the two solid phases occurring together at *r*; at 111°, however, when there is no B in the system there is also solid P as well as NP, this condition corresponding to some point *d* towards the P-end of the PN-axis. For temperatures from 111° to 84°·3 (the fusing-point of BP) each isothermal starts from the BP-axis and ends on the BN-axis, and is made up of stretches *gf*, *fl*, *lm* with P, NP, N respectively as solid phases, P and NP occurring together at *f*, and N and NP at *l*: further, at *p*, where the 84°·3 isothermal cuts the PB-axis, the solid phase BP also occurs with P. Between 84°·3 and 78°·5 the isothermals start from the PB-axis and have stretches *tu*, *uv*, *vw*, *wx*, with BP, P, NP, N respectively as solid phases, two neighbouring solid phases occurring at the junctions *u*, *v*, *w*, but on the isothermal for 78°·5 the points *u* and *v* coalesce into one *o*, which is a quintuple point, since three solid phases are there present with the solution and vapour. For temperatures between 78°·5 and the neighbourhood of 4° three-stretch isothermals *ijyz*

again occur, but with BP replacing P in the first stretch as solid phase. In the neighbourhood of 4° B begins to appear as solid phase, and two quintuple points *k*, *k'* must occur with BP, B, NP and N, B, BP as coexisting solid phases; but this part of the author's diagram is constructed from Schreinemakers' theory and not from experiment. Thus a line *dfo* is the locus of coexisting P and NP solid phases, *ok* of BP and NP, *qk'* of N and NP, *oup* of P and BP, and there will similarly be lines *ka*, *kck'*, *k'b* for the pairs BP and B, NP and B, N and B. The points *k*, *k'* are by theory positions of minimum temperature. R. E. B.

626. *Equilibrium in Three-Component Systems.* III. **F. A. H. Schreinemakers.** (Zeitschr. phys. Chem. 25. pp. 305–331, 1898.)—In a former memoir the equilibrium of such systems, in which two liquid phases, but only a single solid phase (and that one of the components), can occur, was considered; the extended case in which two solid phases, each being a component, may occur, is now investigated, but the results are too intricate for an abstract. The influence of foreign bodies on the transition-temperature of a solid substance in a liquid, *i. e.*, the temperature at which the solid phase of a substance A appears with two solutions, of which one contains more A than B, and the other more B than A, is next considered both experimentally and theoretically, and it is shown that the transition-temperature is raised or lowered by the addition of a third component according as it is the less or the more concentrated solution of the solid in which this third component is the more soluble. R. E. B.

627. *Internal Virial of an Elastic Body.* **J. Finger.** (Wien. Akad. Sitzber. 106. pp. 722–738, 1897.)—It is shown that the internal virial per unit volume is $-\frac{1}{2}(X_x+Y_y+Z_z)$, where X_x is the x-component of stress on a plane normal to the x-axis, &c. It is also expressible in terms of the elastic potential; but for details the paper must itself be referred to. R. E. B.

628. *Characteristic Equation of Liquids.* **M. Thiesen.** (Annal. Phys. Chem. 63. 1. pp. 329–335, 1897.)—Four different hypotheses are examined, viz., that the intrinsic energy is of the form

$$(1)\ V_1+V_2t,\quad (2)\ V_3+V_4p,\quad (3)\ T_1-pv,\quad (4)\ T_2v^{-1}+\beta pv,$$

for each of which some theoretical reason may be assigned, V and T representing functions of v and t respectively. These give for the isometric specific heat expressions of the forms

$$(1)\ V_5,\quad (2)\ F_1(tV_6),\quad (3)\ T_3-F_2(tv^{-1})\equiv T_3+P,$$
$$(4)\ F_3(tv^{-8})+v^{-1}T_4,$$

where F denotes a function and P a function of p. None of these is true for water, and therefore cannot be general. R. E. B.

SOUND.

629. *New Theory of Hearing.* **Hurst.** (Journ. Phys. Chim. Élem. 141. pp. 50–54, 1898.)—The experiments of Kohlrausch and others have established that two waves separated by a suitable interval of time suffice to give the sensation of a note whose pitch is determined by the ear with a certain degree of approximation; the limits of possible error being expressed by the ratio 24/25. When the absolute number of vibrations succeeding each other at the same interval of time goes on increasing up to 16 vibrations, beyond this the precision attained does not vary. These results condemn all the theories founded on "resonance," which attribute the sensation of pitch to the vibration of fibres of the basilar membrane which would answer to the note to which each of them is tuned. The theory proposed by the author explains quite otherwise the correspondence between a given note and a given group of the fibres of the organ of Corti. The main point in the theory is the following:—A single wave sets in motion successively all the fibres respectively of the basilar membrane and the membrane of Reissner; but the motion of these membranes imparts only a motion on the whole to the organ of Corti which they comprise between them, and does not affect the nervous fibres of that organ. As disturbances succeed each other, the direct wave which is transmitted by the basilar membrane crosses the return wave which comes back by the membrane of Reissner; at the point of crossing, the two membranes are sharply caused to approach, and the organ comprised between them is compressed: this compression affects the nervous fibres at the point of crossing. The author endeavours to show that the function of the middle ear is to reinforce low notes and to extinguish relatively high notes. He develops a theory of concord and discord, and replies to objections which may apparently arise from certain pathological observations as to the seat and result of internal lesions. J. J. S.

ELECTRICITY.

630. *Irreversible Wave Motions.* **L. Boltzmann.** (Berlin. Akad. Sitzber. 44. pp. 1016–1018, 1897.)—Planck, in his papers on irreversible wave-motions ('Strahlungsvorgänge'), Berlin. Sitzungsberichte, Feb. 4, 1897, etc. [see Phys. Soc. Abstracts, No. 651, 1897], conceives a space bounded by an absolute reflecting surface. A system of electromagnetic waves is set up in this space according to Maxwell's equations, it being assumed that there is no dissipation of energy. If there be introduced into the space small resonators, Planck maintains that the wave system will be altered in an irreversible manner, and that without dissipation of energy. Boltzmann asserted (June 17, 1897) that if at any instant the magnetic polarisations were reversed, the electric forces and polarisations remaining unchanged, the system of waves must retrace its course, and is in that sense reversible. Planck replied (July 8, 1897) that this reversed motion is inconsistent with his assumed fundamental condition, namely, that the primary wave in the neighbourhood of any resonator is to possess at all times finite and continuous values. Granted, then, that the reversed motion would take place, it does not, he says, contradict his theory. Further, Planck asserted that there is no other case in nature in which irreversible processes take place without dissipation of energy. In the present paper Boltzmann asserts :—

(1) The surface of a resonator may be regarded as part of the bounding absolutely reflecting surface, and can no more give rise to an irreversible process than the bounding surface itself can.

(2) If resonators render irreversible processes possible, then Poincaré's view must be wrong, that irreversible processes cannot be deduced theoretically from the differential equations of pure dynamics.

(3) In the theory of gases there exists a state, or distribution of momenta, more probable than any other (the state in which H is minimum), and a system generally tends to pass into that state; but the reverse motion, in which it would pass out of the state, is mathematically possible, though highly improbable. So in a system of waves there may exist a state more probable than any other. And, precisely as in the theory of gases, the system tends to pass into that state, but the reverse motion is mathematically possible, though highly improbable. The most probable state is called by Boltzmann 'ungeordnet.' The states to which we should apply the term ungeordnet are infinite in number compared with the states to which we should apply the term geordnet. The chance, therefore, that the system being now geordnet shall become after time t ungeordnet, is infinitely greater than the chance that being now ungeordnet it shall after time t be geordnet, although the course by which it passes from a particular geordnet state x to a particular ungeordnet state y may be described in the reverse way from y to x. In that sense the process is irreversible.

S. H. B.

631. *Irreversible Radiation Phenomena.* **M. Planck.** (Berlin. Akad. Sitzber. 52. pp. 1122–1145, 1897.)—In this (which is the third communication by the same author) is considered a space bounded by a perfectly reflecting spherical surface. In this space is set up a system of electromagnetic waves proceeding radially according to Maxwell's equations. In Parts I. and II. the motion is investigated when the sphere is empty.

In Part III. it is investigated when a small resonator is placed at the centre. Let $\phi(t)$ denote the value of any function at time t and distance r from the centre due to the wave-motion when there is no resonator, and let T be the periodic time. Let $f(t)$ denote the same thing for the waves induced by the resonator, then it is found that $\phi(t)+f(t)=\phi(t+\mathrm{T})$. The question is then discussed, what will happen if the magnetic forces be reversed without change of the electric forces. Will the system exactly retrace its course or not? It is found that the above equation

$$\phi(t)+f(t)=\phi(t+\mathrm{T})$$

is not satisfied in the reverse motion. Whence it is concluded that the motion is irreversible, notwithstanding that there is no dissipation of energy or evolution of heat. It is assumed that the components of force due to the spherical wave which excites the resonator are at all points finite and continuous. It is assumed also that certain special cases are excluded.

For previous papers, see Phys. Soc. Abstracts, No. 651, 1897.

S. H. B.

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632. *Lorenz's Theory.* **Lienard.** (Écl. Électr. 14. pp. 417–424 & pp. 456–461, 1898.)—In the first paper M. Liénard shows how certain of Lorenz's results may be obtained by an independent method, including equation 124 of Lorenz's book and with slight modifications equations 145 and 146.

Let $\alpha\ \beta\ \gamma$ denote components of magnetic force;
$f\ g\ h$ „ „ displacement in ether;
$\mathrm{M}_x\ \mathrm{M}_y\ \mathrm{M}_z$ „ „ dielectric polarisation.

We have six fundamental equations among these nine quantities. To obtain three more we must make some new hypothesis. Now for a body at rest and in electric equilibrium we have, X Y Z being components of electric force,

$$\mathrm{X}=4\pi\mathrm{V}^2 f, \text{ etc.}$$

The assumption which, according to Liénard, constitutes the strength of Lorenz's theory is that for a medium in motion these equations do not hold. They must be replaced by

$$X=4\pi V^2 f+\gamma\eta-\beta\zeta,$$
$$Y=4\pi V^2 g+\alpha\zeta-\gamma\xi,$$
$$Z=4\pi V^2 h+\beta\xi-\alpha\eta;$$

$\xi\ \eta\ \zeta$ being components of the convection current.

From which equations are deduced results corresponding to those of Lorenz, as also certain results due to Fresnel and Fizeau.

The question investigated in the second paper is how far Lorenz's theory satisfies the two conditions (1) equality of action and reaction; (2) conservation of energy. $F_x\ F_y\ F_z$ denote ponderomotive component forces on a particle charged with electricity, and $\xi\ \eta\ \zeta$ components of convection current.

I. Considering the equality of action and reaction, we have, $d\omega$ being an element of volume,

$$F_x=\int\frac{\partial}{\partial t}(\beta h-\gamma g)d\omega=\frac{\partial}{\partial t}\int(\beta h-\gamma g)d\omega;$$

where $\frac{\partial}{\partial t}$ denotes change with the time at point fixed in space. Now the condition requires that $\int F_x d\omega=0$, which is not generally satisfied in the above equation. That is because it is assumed that force takes time in its propagation through space, and therefore action and reaction referred to the same instant cannot generally be equal and opposite. It is sufficient to satisfy the principle if on average of time $\int F_x d\omega=0$—and that is satisfied. It is concluded then that Lorenz's theory does satisfy the principle in the only way in which it can be satisfied. M. Liénard holds that in Hertz's theory it is not satisfied.

II. *Conservation of energy.*—In this case we get

$$V^2\Sigma\frac{\partial}{\partial x}(\beta h-\gamma g)d\omega dt=$$
$$\left(4\pi V^2\Sigma f+\frac{\partial f}{\partial t}+\frac{1}{4\pi}\Sigma\alpha\frac{d\alpha}{dt}\right)d\omega dt+\Sigma 4\pi V^2\overline{\rho-S}\xi d\omega dt$$
$$+\Sigma 4\pi V^2 f(u+u_1)d\omega dt,$$

where Σ denotes summation for all particles within $d\omega$, S is the apparent electrification or "charge fictive," u the velocity in x of the medium, u_1 that of a particle relative to the medium. The left-hand member is, according to Poynting's theory, the vector-flow of energy in x. To verify the principle, it is shown that the second member represents the increase of energy within the element $d\omega$ plus the heat evolved plus the work done. It is further shown that the Lorenz theory also explains Faraday's phenomenon.

S. H. B.

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633. *Contact Electricity.* **Pellat** and **Sacerdote.** (Journ. de Physique, 7. pp. 24–28, 1898.)—Suppose a plane condenser formed of two plates of different metals MM′ joined by a metallic

wire *mm'*, and the whole placed in a vacuum. On account of the difference of potential v at contact, the armatures have charges :

$$\pm q = \pm \frac{S}{4\pi e} v,$$

S being the area of the plates, and e their distance apart.

Cause the distance e to increase and decrease periodically within limits so small that they always remain infinitely small compared with the dimensions of the armatures. To these periodical variations of capacity will correspond in the wire alternating currents, and hence disengagement of heat by the Joule effect. The authors set out to prove that this energy set free is integrally equivalent to the work expended to produce these variations of capacity, contact need not be brought in to furnish the energy, and hence it is useless to imagine chemical actions as produced at the contact of the two metals, or of these latter with the dielectric.

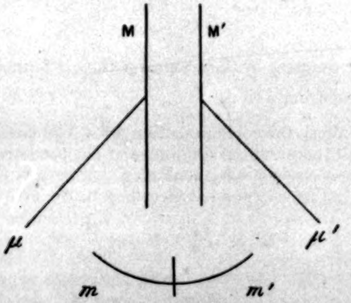
Let the condenser be caused to describe the following closed cycle, the electric attractions being supposed constantly compensated by forces exterior to the system, and the work of these latter being considered :—

1. Let the wires be cut somewhere at $\mu\, \mu'$ and the plates separated to the distance $e + \Delta e$. The work to be supplied in this case is :

$$T_1 = 2\pi\sigma^2 S\Delta e = 2\pi \frac{q^2}{S} \Delta e = \frac{Sv^2}{8\pi e^2} \Delta e,$$

where σ is the surface-density ; the charges have remained constant $\pm q$, and the difference of potential of the armatures has become

$$v + \Delta v = v \frac{e + \Delta e}{e}, \quad \text{or} \quad \Delta v = v \frac{\Delta e}{e}.$$



2. Re-establish communication at $\mu\mu'$. A partial discharge is produced which brings back the difference of potential from $v + \Delta v$

to v, whence, according to the Joule effect disengagement of heat, W_1 (in mechanical units) given by

$$W_1=\int ri^2dt,$$

where r is resistance of connecting thread, and i the value of current at time t. But if L is the coefficient of self-induction of the wire, and V the potential difference at the time t, then

$$L\frac{di}{dt}+ri=V-v,$$

whence, on multiplying the two sides by idt, which

$$=-\frac{SdV}{4\pi(e+\Delta e)},$$

and integrating for the whole duration of the discharge noting that $\int Lidi=0$, we have

$$\int ri^2dt=-\int_{v+\Delta v}^{v}(V-v)\frac{SdV}{4\pi(e+\Delta e)},$$

whence

$$W_1=\frac{S(\Delta v)^2}{8\pi(e+\Delta e)}=\frac{Sv^2}{8\pi(e+\Delta e)}\left(\frac{\Delta e}{e}\right)^2,$$

there remains on the plate the charges

$$\frac{\pm Sv}{4\pi(e+\Delta e)}=\pm q\frac{e}{e+\Delta e}.$$

3. Break the communications $\mu\mu'$ and cause the plates to approach to the distance e. The corresponding work, calculated as in the first operation, is

$$T_2=\frac{Sv^2}{8\pi(e+\Delta e)^2}\Delta e;$$

during this movement by the armatures their difference of potential has descended from v to $v\frac{e}{e+\Delta e}$.

4. Re-establish the communication $\mu\mu'$. The condenser becomes recharged till the potential difference of the plates is again v. Let W_2 be the heat-energy set free during this time in the circuit (the Joule effect); this is expressed according to the above reasoning by

$$W_2=-\int_{v\frac{e}{e+\Delta e}}^{v}(V-v)\frac{S}{4\pi e}dV$$

$$=\frac{Sv^2}{8\pi e}\left[1-\frac{e}{e+\Delta e}\right]^2;$$

the system has returned to its initial state.

The total work supplied $T=T_1+T_2$

$$=\frac{Sv^2}{8\pi e^2}\Delta e\left[1-\left(\frac{e}{e+\Delta e}\right)^2\right]=\frac{Sv^2\Delta e^2(2e+\Delta e)}{8\pi e^2(e+\Delta e)^2}.$$

The heat energy set free, $W_1=W_1+W_2$

$$=\frac{Sv^2}{8\pi(e+\Delta e)}\left(\frac{\Delta e}{e}\right)^2+\frac{Sv^2}{8\pi e}\left[1-\frac{e}{e+\Delta e}\right]^2$$

$$=\frac{Sv^2\Delta e^2(2e+\Delta e)}{8\pi e^2(e+\Delta e)^2}.$$

Whence $T=W$.

The total energy set free in virtue of the Peltier effect by the two currents in opposite directions is zero, since quantities of electricity equal and of opposite sign have passed.—It is to be noted that in the system considered, consisting of two plates MM′, each furnished with a wire *mm′*, and first of all non-electrified, *at the moment of making contact at mm′ the phenomenon of the charge of the condenser is accompanied by a diminution of the energy of the system*; a diminution equivalent to the heat set free according to the Joule effect, the Peltier effect being negligible in comparison. Hence it follows that in an electrified system when the metals which constitute it are not of the same nature, there may be less energy, all the other conditions remaining the same, than when it is not electrified. The expression $\frac{1}{2}\Sigma QV$ for representing the increase of energy acquired by a system on charging is not rigorously exact except in the case in which the metals are of the same nature. J. J. S.

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634. *Rotations in Uniform Electrical Fields.* **E. R. von Schweidler.** (Wien. Akad. Sitzber. 106. pp. 526–532, 1897.)—In 1881 Hertz treated the case of a conducting sphere rotating uniformly about a diameter at right angles to the direction of an electric field in which it was placed. Heydweiller has recently pointed out that in order to generalise this problem it is necessary to consider the opposite case of a dielectric sphere revolving in a conducting liquid. This was done, and led to the conclusion that the couple due to the electric forces acts in the sense of the rotation, instead of against it as in Hertz's case. For the qualitative agreement of this result with Quincke's experiments (Wied. Ann. 59. p. 417, 1896) Heydweiller was led to infer that a great part of the effects observed might be due to this couple.

The present author then proceeds to discuss the general case mathematically, the conductivity of both sphere and surrounding medium being at the outset treated as finite. The chief results of the analysis may be stated thus:—(1) The couple due to the rotation in the electric field is positive (in the direction of the rotation) if the conductivity in the outside medium exceeds that of the sphere, and the couple is negative when the order of the conductivities is reversed. (2) If the sphere is non-conducting the couple reaches a maximum for the angular velocity given by $c\tau=3/4$, where c is the conductivity of the medium in electrostatic units, and τ the period of rotation of the sphere. Thus to get the maximum effects the values of τ are of the following order:—in mercury 10^{-16} sec., in alcohol 2×10^{-6} sec., in benzole 20 sec., and in vaseline oil 200 sec. The couples may reach the value 10 dyne-cm. in favourable cases.

The author has also endeavoured to measure experimentally the couples thus called into play. In the case of rotations in ether, the values were small in comparison with those due to the torsion of the suspension and the viscosity of the liquid. In other cases, as crown glass in benzole, and a large sphere of quartz in carbon disulphide, the values were of the same order of magnitude. While admitting he has not given a complete theory of Quincke's experiments, the author feels that the couples referred to play a significant part in the phenomena in question. E. H. B.

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635. *Dielectric Constants of Liquid Mixtures.* **J. C. Philip.** (Zeitschr. phys. Chem. 24. pp. 18–38, 1897.)—The dielectric constants are measured by means of Nernst's method slightly modified. Arms 1 and 2 of the Wheatstone bridge contain equal electrolytic resistances of small capacity; arms 3 and 4 each contain an electrolytic resistance, a condenser consisting of two brass plates separated by a glass or ebonite plate, by moving which the capacity may be altered to a known extent, and finally a condenser in which the dielectric is the liquid under examination. The two condensers containing liquid are first filled with the same substance; a small quantity of a second substance being added to one of them, balance is disturbed, and to restore it the ebonite plate in the proper air-condenser must be moved so that the change of capacity is equal to that produced in the liquid. In this way the difference between the dielectric constant of the solution and of the pure solvent is obtained with considerable accuracy.

The calculation of the dielectric constants of the mixtures from those of the components is carried out by the formulæ which apply to the refractive index, viz.:—$100\,C=p_1C_1+(100-p_1)C_2$, where C, C_1, and C_2 apply to the mixture and the two components respectively, and p_1 is the percentage of the first component in the mixture. Calling k and d the dielectric constant and density, $C=\sqrt{k}-1/d$ or $k-1/(k+2)d$. The first expression gives results very much nearer the truth than the second, though neither is entirely satisfactory. Some mixtures give entirely abnormal results; for example, mixtures of ether and chloroform, most of which have a dielectric constant greater than 5, whilst the dielectric constants of ether and chloroform are 4·3 and 4·8 respectively.

By means of the $\sqrt{k}$ formula the author calculates the dielectric constants of various alcohols from the dielectric constants of their solutions in benzene and toluene. In all cases the dielectric constants decrease as the solutions become more dilute, and appear to tend towards limiting values which are very considerably smaller than those found for the pure substances. The author connects this change in the dielectric constant with the breaking up of the complex aggregates of alcohol molecules which exist in more concentrated solutions and in the pure substances. Nitrobenzene, the molecules of which show little tendency to form aggregates, gives a dielectric constant which is not affected by dilution. T. E.

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636. *Free Electricity in Geissler Tubes.* **E. Riecke.** (Annal. Phys. Chem. 63. 1. pp. 220–229, 1897.)—The researches of Hittorf on the potentials of points situated on the axis of a Geissler tube filled with nitrogen, and those of Warburg on the fall of potential in the neighbourhood of the kathode, furnish data for the calculation of the volume and surface densities of the charges at various points in the tube. The author has performed this calculation, and gives the results of it in the present paper. The quantities calculated include the surface-densities on anode and kathode and at the boundary of the dark space, the volume-densities at specified distances from the anode, and the electric force at the same distances from the anode; each is calculated for three different strengths of current and for pressures of 0·2 and 0·6 mm. mercury respectively. The results show that the surface- and volume-densities and field-strengths on the anode side of the dark space, and at the boundary of the dark space itself, are independent of the current; alteration of current affects only the kathode. On the other hand, alteration of pressure affects the anode side only, the distribution of electricity round the kathode being the same for a given current whether the pressure is 0·2 or 0·6 mm.

In the second part of the paper the author assumes that electric conduction in gases is due to the convection of electricity by a relatively small number of positive and negative ions mixed with a larger number of unelectrified molecules; the electric density at any point will depend on the difference between the number of positive and negative ions per cubic centimetre at the point. The interval between two collisions of the molecules of such a gas comes out much smaller than if the gas contained no ions. J. L. H.

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637. *Structure of Kathode Light.* **E. Goldstein.** (Berlin. Akad. Sitzber. 40. pp. 905–914, 1897.)—The author has previously shown that the kathode light of induced discharges consists of three distinct kinds of radiation, corresponding to the three layers round the kathode. The first layer nearest the kathode, and the second one are composed of rays emitted in straight lines from the kathode, which penetrate through the third layer. Solid bodies placed in the second layer cast shadows, of which the umbra is filled with light similar to that of the third

layer, whereas bodies immersed entirely in the radiation of the third layer cast no shadow. For brevity, the rays of the second and third layers are referred to as K_2 rays and K_3 rays respectively. Several experiments with tubes of various shapes are described, which show that the K_3 rays are emitted in all directions from every point reached by K_2 rays, and proceed from their origin in straight lines. The rays found in the umbra of bodies screening-off the K_2 rays proceed from points illuminated by K_2 rays which have passed the edge of the screen; if the screen is large enough to cut off all the K_2 rays, its umbra is almost completely dark. Both K_2 and K_3 rays are deflected by a magnet. When K_2 rays impinge on a solid, diffused rays are emitted in all directions, the reflected radiation being most conspicuous, because the transmitted rays are absorbed by the solid, unless its thickness is small. The author supposes that gas molecules behave like solids to these rays, so that kathode rays reflected from the walls of a vacuum-tube and Lenard rays transmitted through the walls are of similar nature, both being K_3 rays. It is, however, open to question whether the radiation resulting from the impact of K_2 rays is of the same kind as the K_2 rays themselves; their colour is usually different, although they are similarly deflected by a magnetic field. J. L. H.

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638. *Interference and Electrostatic Deflection of Kathode Rays.* **G. Jaumann.** (Wien. Akad. Sitzber. 106. pp. 533–550, 1897.)—Several experimenters having been unable to repeat successfully the author's experiments on the interference of the blue kathode light, he describes the details of them more fully. Two parallel rectangular aluminium plates, 10 cm. long, 4 cm. wide, and 2 cm. apart, are connected by a loop of brass wire, 250 cm. long and 0·8 mm. in diameter; a movable binding-screw serves to connect the wire with the negative pole of an influence-machine, and the whole is placed under a receiver which can be exhausted. The wire leading to the influence-machine contains a spark-gap; the anode in the receiver is far removed from the kathode plates, and all contacts must be good. With these precautions, the interference-surface between the parallel kathodes is seen as a clear blue plane of light, surrounded by a pale bluish mantle; the rest of the space between the plates is nearly dark. Displacement of the movable contact along the wire causes a shift of the light towards one or other of the kathode plates, and its edges curve over towards the nearer plate. The author is of opinion that the kathodes do not exert a deflecting action upon the kathode rays, as Goldstein supposes, but that the deflection observed by Goldstein is partly due to interference and partly to electrostatic deflection of the rays. Experiments are described which seem to show that the interference-surfaces for the intense radiation from two kathodes, inclined to each other at an angle, are very similar to those obtained by Mach in the case of sound-waves of great

amplitude: this supports the view of the author that kathode rays are longitudinal ether-waves.

Referring to the experiments of Wiedemann and Schmidt on the displacement of the point of origin of kathode rays by an electrostatic field, the author gives evidence that the rays themselves are deflected after leaving the kathode, in addition to the displacement of their origin. He shows that this is in accord with the longitudinal-wave theory, since a purely longitudinal disturbance can only be propagated along the lines of maximum and minimum electrostatic force; in any other direction transverse waves would accompany it. Finally, experiments are described which show that in certain cases the kathode rays follow the direction of the maximum electrostatic force and do not always proceed in straight lines.

J. L. H.

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639. *Electric and Magnetic Oscillation in Hertz Waves.* **K. Waitz.** (Annal. Phys. Chem. 63. 1. pp. 234–241, 1897.)—The object of the investigation is to show that the electric and magnetic waves possess different damping coefficients when passing through the same conductor. The conductors examined range in conductivity between copper and acetic acid, and the method of measuring the absorption is by constructing resonators in the form of a rectangular circuit. For solids a wire of the material is bent into rectangular shape, and for liquids a glass tube of similar form is used, the ends being connected to an electrometer, as in the experiments of V. Bjerknes. The waves from an oscillator, consisting of two cylinders sparking into each other, are allowed to fall on a slit or grating formed by zinc plates, which allow either the electric or the magnetic wave to pass through, according to its position; the wave is then received on the resonator and absorbed, the amount of absorption being measured by the first swing of the electrometer-needle. In the case of metals the damping is the same for electric and magnetic waves, and corresponds with the values given by Bjerknes. The electric oscillation has a damping-coefficient increasing with decrease of conductivity of the material; the absorption of the magnetic oscillation, on the other hand, first increases and afterwards decreases again as the resistance is increased. Its value is a maximum for a specific conductivity of approximately 20×10^{-8}. The anomalous electric dispersion and absorption of glycerine, amyl alcohol, ethyl alcohol, and acetic acid have previously been investigated by Drude (see Phys. Soc. Abstracts, No. 444, 1896.)

J. L. H.

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640. *Coherers.* **C. Rovelli.** (Elettricità, Milan, 17. pp. 36–37, 1898.)—The author uses a coherer made up of iron filings, with two thin wire contacts. It is only found necessary to touch the wires or even to blow upon them, in order to restore the needle to its position; it is not necessary to shake the iron filings. The inference is that the change in the filings is confined to the

immediate neighbourhood of the wires; and the author thinks the action of the electric wave produces an increase in the difference of potential at the ends of the wires immersed in the iron filings. The necessity for this latter conclusion is questioned by R. Malagoli (Elettricità, Milan, 17. pp. 102–103, 1898). A. D.

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641. *Blindness from the Electric Arc.* **A. J. Rowland.** (Amer. Electn. 10. pp. 107–108, 1898.)—The author describes the well-known symptoms of inflammation of the conjunctiva, or outer membrane covering the front of the eyeball, due to looking at arcs taking large currents without proper guards for the eyes. The author recommends, in cases of a slight attack, either of the following eyewashes:—Six grains of borax in a fluid ounce of infusion of sassafras-pith, or ten grains of boric acid in an ounce of camphor-water. In a very bad case a *physician* should apply cocaine. In protecting the eyes against the burning power of arcs taking large currents, it is not sufficient to wear such glasses as are made for those who repair and adjust common arc lights; far too much light gets round them. It is necessary to use a mask covering the whole face. E. C. R.

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642. *Surface Travel on Electrolytes.* **W. E. Fiske** and **W. D. Collins.** (Amer. Jour. Sci. 5. pp. 59–62, 1898.)—The electrolyte, a saturated solution of copper sulphate, was contained in a tank a metre long and a square decimetre in section. The electrodes were of sheet copper, equal in area to the section of the tank. The distance between them could be altered so as to give a column of variable resistance. The first process was to measure the resistance of the solution by Kohlrausch's method. Next, with the solution in series with a spark-gap, a photograph of the spark was taken and the number of half-oscillations corresponding to the length in question was plotted against its ohmic resistance. This was done for lengths of solution of resistance from 6 to 24 ohms. Manganin wires of different lengths were then put in the place of the electrolyte, and the operations repeated. The curves thus obtained were compared. The wires showed no surface-travel. An examination of the diagrams of the most reliable results shows that the points on the solution-curves unquestionably tend to fall below those on the wire-curves. The evidence is in favour of a surface-travel in the electrolyte. The investigation is to be continued, using an apparatus giving a higher period. S. S.

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643. *Polarisation in Alcoholic Solutions.* **E. Haschek.** (Wien. Akad. Sitzber. 106. pp. 580–589, 1897.)—The alcohol used was 99·7 %; had specific gravity at 17° C. of 0·7945, and conductivity

39×10^{-11}. On account of the high resistance of the solutions, the E.M.F. of polarisation increases slowly. The maximum of polarisation is higher for alcoholic solutions than for the corresponding water solutions. The polarisation falls with increase of temperature in alcoholic solutions, as it does in aqueous solutions. In the neighbourhood of the boiling-point the fall is exceptionally rapid for salt solutions. With rising concentration the polarisation falls, and more rapidly than the concentration increases. S. S.

644. *Action of Drop-Electrodes.* **W. Palmaer.** (Zeitschr. Phys. Chem. 25. pp. 265–283, 1898.)—Two tubes containing 1/10 saturated HgCl are connected vertically by a narrow tube, and mercury allowed to drop from a capillary point in the upper tube, through the connecting tube, into a reservoir of mercury in the lower. The calomel is found to be abstracted from the solution in the upper tube and restored to that in the lower, where the drops unite with the reservoir. The concentrations are too small to allow of this being demonstrated by chemical means; but the variation is shown by parasitic electrodes of mercury, which become negative in the upper and positive in the lower tube when the dropping takes place. This verifies Nernst's theory of the mode of action of drop-electrodes, that the mercury ions are deposited on the expanding drop, carry the chlorine ions in the double-layer down with the drop, and reunite with them when the drop is lost in the surface of the reservoir. Quantitative results show that the concentration-change proceeds to a high degree, but is limited by the unavoidable mixture caused by the drops falling through the connecting tube. B. B. T.

645. *Electrocapillary Phenomena.* **H. Luggin.** (Zeitschr. Elektrochem. 4. pp. 283–289, 1897.)—A lecture expounding the leading facts, and the theories of Lippmann, Helmholtz, and Nernst, with description of various lecture experiments. B. B. T.

646. *Sullivan Galvanometer.* (Elect. Rev. 42. pp. 592–593, 1898.)—The paper gives an account of trials made on a Sullivan galvanometer when subjected to excessive vibration on a torpedo-boat. The galvanometer was placed on a pad of hair-felt 1½ inch thick in a tray somewhat larger than the galvanometer-base. At each corner of the galvanometer-base and of the tray were fixed screws, and between the pairs at each corner were stretched india-rubber bands, forming an elastic stay sufficient to keep the galvanometer in position. Under the worst conditions of vibration, with the galvanometer immediately over the propeller and on open circuit, the spot of light remained quite steady, except for occasional throws of 5 divisions, increasing at intervals up to

20 divisions. An ordinary marine galvanometer under the same conditions vibrated to such an extent that the spot continually left the scale, rendering any measurements impossible. G. H. Ba.

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647. *Permanence of Manganin Resistances.* **W. Jaeger** and **St. Lindeck.** (Zeitschr. Instrumentenk. 18. pp. 97–106, 1898.) —In the course of the experimental work upon standards of resistance at the Reichsanstalt since 1891, comparisons have from time to time been made between the mercury standard and manganin coils. The results are presented in the form of tables. It now appears that manganin copies of the standard ohm may have even greater constancy than mercury copies. Special precautions have been taken in the design, manufacture, and protection of the manganin resistances to attain this result (see Wissensch. Abhandl. of the Reichsanstalt, Vol. 2). The observed change in a manganin ohm, during the whole period, in no case exceeds a few hundred-thousandths of an ohm. Incidentally, a coil of "patent nickel" is included in the tables; this alloy appears to have the same order of constancy as that of manganin. [For "patent nickel," see Elect. Rev. 42. p. 536 *et seq.*, 1898.] Mercury resistances *diminish* in resistance with time; in five or six years this diminution may amount to about a ten-thousandth of the nominal value of the resistance of the whole mercury column. With manganin the tendency is for the resistance to *increase*; the greatest change observed in a one-ohm coil is 55 millionths of the total resistance, in 5⅓ years.

The second part of this investigation relates to tests of the constancy of manganin resistances of fractional parts of an ohm, such as are used in practice for current tests on electric-light and power circuits. The greatest variation occurred in a wire of 0·1 ohm: the change is a little more than 0·01 per cent. in 2½ years. Details as to soldering and varnishing are not given.

Lastly, the authors describe the tests made on manganin coils of high resistance. It is here that finer wires have to be used; these are necessarily harder than those of greater gauge, for they cannot be annealed, and are therefore drawn cold [see Elect. Rev. *l. c.*]. The consequence is a very decided variation of resistance with time: a coil that was 10003·13 ohms in February 1895 fell to 10002·91 by the following June; it increased to 10004·14 by February 1896, and fell again to 10003·78 in January of the present year. The extreme limits of variation for coils of manganin, of the nominal values specified, are stated to be as follows:—

Nominal Value.	Variation per cent.
From 1–10 ohms	0·01
„ 100–1000 „ or from 0·1 -0·01 ohm..	0·015
„ 1000–10000 „ „ 0·01 -0·001 „ ..	0·02
From 0·001-0·0001 „ ..	0·03

Corresponding to a particular variation, the table shows two ranges of values of resistance, a higher and a lower. The best range is between 1 and 10 ohms; the higher range introduces the imperfectly annealed manganin; the lower range is probably affected by solderings or end-contacts. R. A.

648. *Capacity of Coiled Cables.* **A. Dearlove.** (Electrician, 40. pp. 783-784, 1898.)—The simplest method for measuring capacity is by comparison of so-called "direct deflections." But in the case of a cable whose length exceeds a few n.ms., this method is generally regarded as inapplicable, especially if the cable is coiled—the usual condition in the factory and on board ship. It is well known that the device of connecting the two ends of the coiled cable directly together, and charging and discharging at the "double end," gives better results than when testing from only one end. The author points out that the effect of this "double-ending" is (1) to eliminate the effect of the self-induction of the circuit, and (2) to diminish its resistance. Experiments are described from which it is clear that the "true capacity" of a coiled cable of 444 n.ms., 155·4 mfds., is easily to be determined by "direct deflection" when the two ends are available. By "true capacity" the author probably means the capacity calculated by summing the factory-values of each separate 3-n.ms. drum of core from which the cable is constructed. With the 444 n.ms. of cable, the error introduced by the "direct-deflection" method, testing from a single end, is 18·5 per cent. The error, testing from the double end, is practically *nil*. Some useful figures are given illustrating the errors that may be introduced by employing galvanometers of different "decrements." For instance, a cable whose "true capacity" per n.m. was 0·350 appeared to have a capacity of 0·299 when the galvanometer had a period of 0·85 sec., and a capacity of 0·353 when the period of the galvanometer was 3·125. Finally, the author shows the extent of the errors introduced into "direct-deflection" capacity-tests if an ordinary shunt is applied to galvanometers of the d'Arsonval type; the error may easily be 300 per cent. The same test may be made with the "universal" shunt of Ayrton and Mather, to within 1 per cent. R. A.

649. *Electric Conductivity of Copper.* **S. Sheldon.** (Elect. Rev. 42. pp. 525-526, 1898.)—In order to investigate the relation between annealing and electrical conductivity, a sample of copper was passed several times through a draw-plate until it became very hard. The wire was then cut up and annealed in separate lengths at different temperatures, (1) in a vacuum, (2) in hydrogen, with the results shown in the following table:—

Annealed in a vacuum.		Annealed in hydrogen.	
Annealing Temperature.	Conductivity per cent.	Annealing Temperature.	Conductivity per cent.
° C.		° C.	
20	101·5	20	99·0
37	101·5	45	99·0
54	101·5	105	99·3
118	101·6	234	99·8
215	102·0	360	101·0
300	102·1	483	101·9
600	102·4	1050	89·3
755	102·7		
930	99·0		

R. A.

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650. *Resistance of Electrolytes.* **P. C. McIlhiney.** (Indus. and Iron, 24. pp. 245–246, 1898.)—A method is described for measuring the resistance of electrolytes. It is a slight modification of the ordinary potentiometer method. The electrolyte is first connected in series with a known resistance, and the potential difference at the terminals of the known resistance is observed. For the second operation, the electrolyte is replaced by a second known resistance, the first known resistance being still in circuit. The potential difference is again observed at the same points as before. At the terminals of the electrolyte the current is alternated by a rotary reverser, but the current through the known resistances is always direct. This method would probably be useful where approximate and rapid measurements are required to be made with a single galvanometer or voltmeter of direct-current type. R. A.

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651. *Platinised Electrodes.* **F. Kohlrausch.** (Annal. Phys. Chem. 60. 2. pp. 315–332, 1897.)—The platinising solution employed by Lummer and Kurlbaum for their bolometers is very useful for coating electrodes for the measurement of electrolytic resistances. It consists of 1 part $PtCl_4$ to 0·008 of lead acetate and 30 of water. It gives by electrolysis a dull, deep, platinum black, and produces a well-defined minimum of tone when used in the telephone method. Even in the case of a normal NaCl solution with only 1·74 ohms resistance and electrodes of 10 sq. cm. surface, the resistance was determined with an error of only 0·5 per cent. The new method of platinising is especially valuable on account of the smaller electrodes which can now be employed.

Even with only 0·5 sq. cm. of surface a useful minimum is obtained for resistances as low as 100 ohms. The minimum is greatly improved by thickening the deposit by further electrolysis, and the error in the determination of 20 ohms may thus be reduced to one or two thousandths. The author describes various forms of such electrodes, either fixed or movable. To insure wetting of the electrodes by water, they should be first treated with a drop of alcohol. The electrodes are more delicate than those previously used, and therefore require careful protection when not in use.

E. E. F.

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652. *Thermopiles.* **H. Rubens.** (Zeitschr. Instrumentenk. 18. pp. 65–69, 1898.)—The Melloni thermopile as generally constructed has the objection of sluggishness and a doubtful zero; it has come to be regarded as incapable of the sensitiveness of the bolometer and the radio-micrometer. By reducing the thermal capacity of the parts, the author has succeeded in making an instrument of extreme sensitiveness. He rejects antimony and bismuth, for mechanical reasons, and uses iron and constantan, both of which can be drawn into fine wires of sufficient strength. The heat-receiving junctions are arranged in a single line, 1 mm. apart. With an instrument formed of 20 couples he obtains 0·00106 volt per 1° C.; the resistance from terminal to terminal is 3·5 ohms. Assuming that his galvanometer-scale can be read to within 0·1 mm., he is able to measure with certainty to one-millionth of 1° C., a sensitiveness that compares very favourably with the instruments of Langley and Boys.

Reference is given to a paper by A. Crova (Compt. Rend. 125. p. 894, 1897), who seems to have been the first to apply an iron-constantan couple to a practical purpose. Iron-constantan gives 53 micro-volts per 1° C., about half the E.M.F. of antimony-bismuth; the advantage is therefore only due to mechanical causes. The linear arrangement of the couples is for convenience in spectrum experiments; the author proposes to use them in the place of cross-wires. Owing to its small thermal capacity, the instrument responds with sufficient rapidity for such measurements.

R. A.

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653. *New Species of Transition-Cell.* **E. Cohen.** (Zeitschr. phys. Chem. 25. pp. 300–304, 1898.)—The author shows from the measurements of Callendar and Barnes (Proc. Royal Soc. 42. p. 117, 1897), that the Latimer-Clark cell is a fourth and simpler form of the transition-elements described by himself, Bredig, and van't Hoff. The E.M.F. is represented by two curves intersecting at 38°·75: the solubility (determined by C. and B.) shows a transition-point at 39°·9. The author finds with the dilatometer 38°·5. From the work of Jaeger (Annal. Phys. Chem. 63. 13. p. 354, 1897) on the E.M.F. with $ZnSO_4 7H_2O$ and $ZnSO_4 6H_2O$ the transition-point is found to be 39°.

B. B. T.

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654. *Clark Cells on Closed Circuit.* **T. Wulf.** (Wien. Akad. Sitzber. 106. pp. 562–579, 1897.)—These measurements have been made on small cells of standard pattern, and not on specially large cells as did Skinner, Phil. Mag. 38. p. 271. The results shortly stated are:—

(1) The internal resistance of the cells (cylindrical glass vessels of 2 cm. diameter, distance of electrodes 3–4 cm.) was at the ordinary temperature between 40 and 80 ohms, varying with the distance and size of the electrodes (active surface of zinc rod 2–3 cm.^{2}).

(2) The internal resistance changed very rapidly with temperature so as to treble itself between 30° and 5° C.

(3) A diminution of internal resistance with the strength and duration of the current could not be stated with accuracy.

(4) Polarisation occurred with strong currents of 0·005 ampere after 0·1 second. It increased only slowly in the first 10 minutes, afterwards more quickly.

(5) After breaking the current the polarisation sank to a small fraction in a few minutes. After repeated short-circuiting through only 50 ohms external resistance for a minute and longer, the E.M.F. of the open element was not permanently affected.

(6) Similarly a cell, circuited for 2 hours with 200 ohms, by which its E.M.F. was reduced to almost half its usual value, after 2 minutes reached its original value to within 0·1 °/₀.

The author measured the E.M.F. of the cells by means of a condenser and ballistic galvanometer. A mechanical key actuated by a falling body was used for contacts of short duration. S. S.

655. *Thermo-electric Batteries and the Jacques Cell.* **C. J. Reed.** (Amer. Electn. 9. pp. 118–120, 1897.)—Thermo-electric batteries are divided into two classes:—(1) Those which consist of conductors in contact which are incapable of electrolytic decomposition. (2) Those containing electrolytes. The first are well known and of very low efficiency, though permanent. The second have a much higher efficiency, and owing to the chemical action which takes place, and is proportional to the current, they require frequent renewal in the same way as a primary battery. In this second class should be included such cells as the Jacques cell, and the tin-chromic-chloride cell due to W. E. Case. Another cell of the same class results by the immersion of two copper U-tubes in a solution of copper sulphate, one tube being traversed by cold water and the other by steam. Electrolytic oxidation of the carbon in the Jacques cell is due to the current flowing, but is not the source of the energy. No proof has been given that carbon can be oxidised at low temperatures with evolution of energy. W. R. C.

656. *Oxidation of Carbon without Heat.* **W. E. Case.** (Amer. Electn. 9. pp. 224–225, 1897.)—The author denies the statement of C. J. Reed (see previous Abstract) as to the

oxidation of carbon at low temperatures, by refering to his own experiments, in which he found that carbon is oxidised by chlorine peroxide, and that an E.M.F. as high as half a volt can be so obtained. Processes occurring in nature are also referred to.
W. R. C.

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657. *Thermo-electric Batteries and the Jacques Cell.* **W. A. Anthony.** (Amer. Electn. 9. p. 225, 1897.)—The author objects to the statement of C. J. Reed (see Abstract No. 655) that the Jacques cell is thermo-electric. There is no evidence that a high and a low temperature are required. It is improbable that the continuous application of heat is necessary: the cell only requires to be placed where the temperature is sufficiently high. In order that the thermo-electric theory should stand, it must be shown that a difference of temperature is requisite and that heat disappears when the circuit is closed, or the temperature rises when the circuit is open. The same remarks apply to the tin-chromic-chloride cell. If the latter were normally at the higher temperature it would maintain its action continuously like any other primary cell.
W. R. C.

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658. *Thermo-electric Batteries and the Jacques Cell.* **C. J. Reed.** (Amer. Electn. 9. pp. 266–267, 1897.)—In reply to Case and Anthony (see the two previous Abstracts), the author refers to previous papers (see Phys. Soc. Abstracts, No. 502, 1897) in which he has shown that the voltaic theory is untenable in the case of the Jacques cell. With regard to the tin-chromic-chloride cell, the materials are not renewed in the same way as in a primary cell. In the latter, potential energy is added by placing new materials in position which have more available energy than the old ones; but in the tin-chromic-chloride cell the exhausted materials are renewed simply by cooling, *i. e.* by abstracting more energy: it is not therefore merely voltaic. Case's experiments upon the oxidation of carbon cannot be regarded as at all conclusive as they are wanting in quantitative details. **W. A. Anthony** (Amer. Electn. 9. p. 310, 1897) replies that the Jacques cell may be voltaic because the reactions taking place, viz. the oxidation of carbon and the formation of carbonate from the alkali, are both exothermic. No reduction takes place. It has not been shown that the introduction of cold air is necessary for the working of the cell; probably the action would occur equally well if the air were heated before entering the cell to a temperature higher than that of the bath. With regard to the E.M.F. found when two electrodes of the same metal at different temperatures are immersed in the same electrolyte, there is no reason for saying that it is thermo-electric. The work of C. Liebenow and L. Strasser has shown it to be due to the variation of chemical affinity with temperature. The same work has shown that the air acts simply as a depolariser. **C. J. Reed** (Amer. Electn. 9. pp. 310–311, 1897) remarks that the view taken by Anthony as to the exothermic character of the reactions in the Jacques cell involves the

idea that the electrolyte undergoes no chemical change except by combination with carbon dioxide; that the electrical energy is due in part to the direct combustion of carbon with free oxygen instead of oxygen derived from the decomposition of the electrolyte, and in part to the secondary reaction involved in the formation of carbonate. For voltaic action some compound must be decomposed. As all the possible decompositions are endothermic, absorption of heat is necessary and the action cannot be voltaic. Referring to the question of two electrodes of the same metal at different temperatures, the reaction in this case cannot be voltaic, for if the conditions could be maintained so that no loss of heat took place, the arrangement would constitute an inexhaustible source of electrical energy. **W. A. Anthony** (Amer. Electn. 9. p. 351, 1897) in reply, remarks that reduction of Fe_2O_3 to FeO is a possible reaction which is not included by Reed, and that the effect of oxygen forced into the cell at the other electrode should not be neglected. No assumption should be based upon the action at one electrode only. On the whole, more energy is evolved within the cell than is sufficient to account for the electrical energy developed, and the cell would maintain itself hot after the action has once commenced if sufficiently protected by a non-conducting covering. There is plenty of energy for the required reaction. Oxygen is ready to combine with the freed ions before they have united to form physical masses. Decomposition takes place just as in any other galvanic cell, being determined by the affinities at both ends of the line. Only the final result need be considered, without the intermediate steps. A certain amount of energy may be necessary to cause decomposition when ions are aggregated into physical masses, but it does not follow that the same amount of energy is required when some other substance stands ready to seize upon the molecules of the ion as fast as they are liberated, forming a new compound with evolution of energy. With regard to two electrodes of the same metal at different temperatures, Anthony does not suppose that a continuous supply of energy could occur. If iron, for example, is dissolved at one electrode, it is not necessarily deposited at the other. The energy probably comes from chemical action within the electrolyte, due partly to absorption of oxygen. **C. J. Reed** (Amer. Electn. 9. pp. 351–352, 1897) recapitulates his previous objections to a voltaic theory, and then remarks that, because the oxidation of the carbon furnishes enough energy to account for the electrical energy developed, it does not follow that the energy is sufficient to decompose the electrolyte. The question is not whether the cell evolves less electrical energy than that contained in the carbon consumed, but whether it could be accomplished through decomposition of the electrolyte without absorption of external heat. The reduction of Fe_2O_3 to FeO, as proposed by Anthony, would require more energy than the carbon contains. Moreover, at the temperature of the cell, carbon would reduce this to metallic iron; besides which, ferric oxide is insoluble in the alkali and would thus not form an electrolyte. Further, Elihu Thomson has shown that metallic iron and not ferrous oxide is formed at the cell-wall. **W. A. Anthony** (Amer. Electn. 9. p. 392, 1897) does not deny that the energy evolved in the oxidation of the carbon is insufficient to decompose the electrolyte, but such is of no consequence. Oxygen is forced in through the positive electrode and thus acts as a depolariser, the reaction being similar to a two-fluid cell. Its effect cannot be neglected, and it is certain that the union of the oxygen with the positive ion furnishes exactly the energy required for the decomposition of the electrolyte. **C. J. Reed** (Amer. Electn. 9. pp. 392–393, 1897), in reply, compares the Jacques cell to an exhausted Daniell through which air is forced. As to oxygen being a depolariser, it in no way resembles depolarisers in two-fluid cells. In the latter, the depolarisers are decomposed in strict accordance with Faraday's law. Oxygen is supplied by reduction of some compound, not from a fluid impregnated with free oxygen. W. R. C.

659. *Electricity direct from Coal.* **C. J. Reed.** (Elect. World, 31. p. 92, 1898.)—The author refers to the cell invented by S. H. Short, consisting of carbon immersed in fused lead oxide, the other pole being a mass of melted lead. This arrangement is preferable to the Jacques cell inasmuch as CO_2 is the only by-product. In most primary batteries an expensive part of the mechanical structure is destroyed, the cost of which is greater than that of the necessary active material. If a suitable containing vessel can be found, this should not be the case in the Short cell. The reaction is simply one of displacement of lead by carbon. W. R. C.

660. *Borchers' Cells.* **C. J. Reed.** (Elect. World, 31. pp. 125–127 & 190–191, 1898.)—The author criticises the various carbon consuming cells invented by Borchers. The action of the first cell, described in 1894, cannot be due to the oxidation of CO and reduction of cuprous chloride, as stated, for such a reaction absorbs heat. The heat of formation of cuprous chloride, on the other hand, from cupric chloride is sufficient to account for the E.M.F. observed. Various omissions are pointed out in the description of the later cells. In the 1894 cell the CO electrode was negative, while in the 1897 cell it is positive. Some experiments are described, which cannot be well abstracted, showing that, contrary to the statement of Borchers, the results depend partly upon the nature of the electrodes and very little upon the gases that are introduced. W. R. C.

661. *Blumenberg Carbon Consuming Cell.* (Indus. & Iron, 24. pp. 227–228, 1898.)—This cell consists of a carbon plate immersed in a fused electrolyte of lime, cryolite, and caustic soda contained

in a metallic bath. Steam is forced through the electrolyte, which should contain oxides or oxygen-bearing compounds. These give up oxygen to the carbon, forming CO and CO_2, and then apparently take up oxygen again from the decomposed steam. In place of oxygen-bearing compounds, natural metallic oxides may be used, in which case the metals are reduced. W. R. C.

662. *Koepsel's Instrument for measuring Magnetic Induction.* **H. Kath.** (Zeitschr. Instrumentenk. 18. pp. 33–39, 1898.)—This is an improved form, brought out by Siemens & Halske, of Koepsel's instrument for the direct reading of magnetic induction in test bars (Zeitschr. Instrumentenk. 14. p. 391, 1894). It may be described as a D'Arsonval galvanometer used inversely, *i. e.*, instead of measuring the current in a movable coil suspended in a field of constant strength, it measures the field when a constant and known current is sent through the movable coil. It consists of a heavy soft iron semicircular yoke, with a magnetising coil, without iron core, along its diameter. The test rods, 6 × 24 mm., are inserted in the axis of the coil through holes in the yoke. In the centre of the yoke is pivoted a coil with pointer similar to that of the Weston instruments. The magnetising effect of the fixed coil when without the test core is compensated for by two windings on the yoke in series with the coil and acting in opposition. Auxiliary apparatus is provided as follows:—A circular resistance-box for giving the magnetising current suitable values for taking a cycle; another resistance-box with three dials for fine adjustment for regulating the current through the movable coil to the value required for direct reading, namely, the constant of the instrument divided by the section of the test-rod in sq. cms.; a special plug switch-board in connection with a Siemens & Halske milli-ammeter, which latter measures the movable coil current directly, and the magnetising current when shunted. A deflection of 1° on the shunted ammeter, corresponding to 0·01 ampere, gives unit magnetising force. G. H. Ba.

663. *Koepsel's Instrument for measuring Magnetic Induction.* **E. Orlich.** (Zeitschr. Instrumentenk. 18. pp. 39–43, 1898.)—The paper describes experiments undertaken at the Physikalisch-Technische Reichsanstalt on the old and new forms of Koepsel's instrument (Abs. above). The B. H. curves of soft iron and steel were taken by the two forms of the instrument and also on the large yoke of the Reichsanstalt. The results show that for soft iron the new instrument gives exceedingly accurate values, and for steel somewhat less accurate but sufficiently so for all practical purposes. The new instrument shows a marked improvement over the old. The following points have to be attended to in using the instrument:—It must be so placed that the earth's field

has no effect; all magnetic bodies and masses of iron must be kept at a considerable distance; the test-rods must not project beyond the yoke. G. H. Ba.

664. *Magnetic Susceptibility of Liquids.* **G. Jäger** and **S. Meyer.** (Wien. Akad. Sitzber. 106. pp. 594–622, pp. 623–653, 1897.)—The first paper contains a description of the apparatus used, and also gives the results of experiments on water and on solutions of ferric chloride; and the second paper gives the results of experiments on solutions of the chlorides, sulphates, and nitrates of iron, manganese, cobalt, and nickel. The liquid to be experimented on was placed in a U-tube having a very long horizontal bottom part. One of the vertical limbs was placed between the poles of a large ring electro-magnet, and the meniscus in this limb stood at the level of the centre of the pole-pieces. The other limb was connected above to a closed cylindrical air-chamber which was again connected to a capillary mercury manometer. When the magnet was excited a displacement of the meniscus between the poles resulted. To restore the meniscus to its former level, a certain change had to be made in the pressure of air in the air-chamber, and this was effected by altering the volume of the air by means of the mercury in the manometer. The change in the volume of the air was read off on the graduated limb of the manometer, and the change in pressure calculated therefrom by Boyle's law, the total volume of air being known.

The strength of field was calculated from the damping of a small closed rectangular circuit when set to vibrate in the field. For this purpose the small circuit was attached to a pendulum whose axis of suspension coincided with the long diameter of the circuit. The damping being measured when the magnet was excited and when not, and the moment of inertia of the pendulum being known, the strength of field was easily calculated.

The experiments with water were made at temperatures from 2° C. to 90° C., and with field-strengths varying from 100×10^6 to 300×10^6 C.G.S. The susceptibility is independent of the magnetising force, but not of the temperature. It is given for water by the expression

$$\kappa = -0{\cdot}647(1 - 0{\cdot}00164\,t)10^{-6}.$$

With all the solutions experimented on, the authors find that the susceptibility is independent of the magnetising force and is proportional to the number of gramme-molecules per litre of solution. The temperature coefficients are negative but vary with the concentration. The susceptibilities appear to be due only to the metallic part of the salt, as the same values are obtained for it per molecule, from solutions of chlorides, sulphates, and nitrates of the same metal. The susceptibility per molecule of nickel, chromium, cobalt, iron, and manganese at the same temperature appears to be proportional to the numbers 2, 3, 4, 5, 6 respectively. J. B. H.

ELECTRO-CHEMISTRY AND CHEMICAL PHYSICS.

665. *Speed of Chemically acting Molecules in a Gas.* **M. Cantor.** (Annal. Phys. Chem. 62. 3. pp. 482–489, 1897.)—A metal plate immersed in a gas which acts chemically upon it undergoes less pressure than if it were unacted on, since some of the molecules which impinge on it are not reflected from it. Assuming these molecules to be those with energy between given limits or with speeds between v_1 and v_2, the pressure on the plate is less than on an inactive plate by $K=\frac{1}{6}\rho\int_{v_1}^{v_2} v^2 dV$, and the plate will increase in mass by $\mu=\frac{1}{4}\rho\int_{v_1}^{v_2} v dV$ per unit time and area, if ρ is the density of the gas and dN the proportion of molecules with speed between v and $v+dv$. Thus $3K/2\mu \equiv \int_{v_1}^{v_2} v^2 dN / \int_{v_1}^{v_2} v dV$ may be roughly taken as a measure of the speed of the active molecules.

The author placed a copper plate in chlorine and found $\mu=\frac{1}{3}\times 10^{-6}$ gm. per sec. per sq. cm.; he also hung it with its plane vertical and with the front of one half and the back of the other covered with glass, and on substitution of chlorine for air found deflections which indicated K=1070, 1700, 1820 microbarads in three separate experiments, the first with a bifilar and the others with a single quartz suspension. Taking 1530 as the mean value, we obtain 69 metres per second as rough estimate for the speed of the active Cl molecules. These experiments were repeated with Cu in NH_4Cl, but the results are withheld for the present for more careful discussion. R. E. B.

666. *Mobility of Molecules.* **H. Euler.** (Annal. Phys. Chem. 63. 1. pp. 273–277, 1897.)—The author has measured the velocity of diffusion of the halogens by a method analogous to Scheffer's, and infers from the results that the diffusion-coefficients of the *molecules* Cl_2, Br_2, I_2 in water, as well as in other solvents, are *ceteris paribus* inversely proportional to the square roots of their molecular weights. Results of Hüfner are quoted for aqueous solutions of gases, which appear to follow a similar law. There appears to be no simple connection between the atomic weight of inorganic ions and their mobility as determined by electrolysis: this the author thinks may be accounted for by the hydration of the ions.

G. B. M.

667. *Phase-rule and the Physical Properties of Chemical Compounds.* **F. Wald.** (Zeitschr. phys. Chem. 24. pp. 315–324, 1897.)—Gibbs' rule $v=\nu+2-r$, connecting the number of independent

variations of a system (n) with the number of phases (r) and the number of independent elements (ν), is discussed in detail, especially the particular case of $r=\nu$, which "supplies the key to the understanding of the gaseous laws and makes intelligible other physical relations between chemical compounds." The laws themselves, however, are not deducible from the principles laid down.

R. E. B.

668. *Chemical Action of Electric Oscillations.* **A. v. Hemptinne.** (Zeitschr. phys. Chem. 25. pp. 284–299, 1898.)—Volatile liquids were submitted in the form of vapour at 15 mm. pressure to electric oscillations from a Lecher's apparatus for a few minutes up to two hours, and were all found to be decomposed. Analysis of the gases show that methyl and ethyl alcohols give large quantities of methane and ethane respectively, with 20–30 °/₀ CO, some CO_2, and 25–30 °/₀ H_2. The author concludes that O is first split off, which then attacks the hydrocarbon. Decomposed in presence of phosphorus, to absorb the O, ethyl alcohol yields much less CO. The decomposition of propyl, isopropyl, and allyl alcohol indicates a similar phenomenon. Aldehyde, paraldehyde, and acetone seem to first split off CO: the presence of P has no effect on the decomposition products. Acetic and propionic acids apparently split off O_2 at first; formic acid yields CO_2 and H_2. The isomeric esters, methylacetate and ethylformate, yield identical products, in contradistinction to the isomers allylalcohol, propylaldehyde, and acetone. The author concludes that the point of greatest weakness to mechanical [electrical] stress is not to be determined from constitutional formulæ derived from chemical reactions. Liquids and solid substances are decomposed by the direct action of the oscillations. Glycerine gives CO_2, CO, and H_2; glyceric acid gives, in addition, 20 °/₀ methane. Glycol gives 12 °/₀ methane, and seems to decompose into $CH_4+CO_2+3\,H$. Glyoxal, glycollic acid, oxalic acid, benzene, phenol, and benzoic acid are decomposed.

B. B. T.

669. *Interrelations of Chemical and Electrical Energy.* **J. Klaudy.** (Zeitschr. Elektrotechn. Wien, 16. pp. 55–57, 151–153, 161–163, 1898.)—An epitome of recent theories on the chemical action in primary cells, their resistance and electromotive force.

B. B. T.

670. *Boiling-points of Salts in Ethereal Solution.* **R. Lespieau.** (Comptes Rendus, 125. pp. 1094–1096, 1897.)—Using Raoult's apparatus, it has been found that it is not possible to deduce from a single measurement the molecular weight of a salt dissolved in ether. The numbers obtained vary very rapidly with concentration, and the limit towards which they tend when the concentration diminishes indefinitely should be sought. This limit has been

calculated assuming (which graphic treatment of the results shows to be allowable) that the curves obtained on taking as abscissæ the rise in boiling-point Δ_T, and as ordinates the ratio of Δ_T to the quantity of the substance dissolved, are straight lines. The numbers got by the application of Raoult's methods may be multiples or sub-multiples of the true molecular weight. J. J. S.

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671. *Freezing-points of Benzene Solutions.* **R. Mihály.** (Zeitschr. phys. Chem. 24. pp. 13–17, 1897.)—In a solution of 3·9994 grams of alcohol in 17·15 grams of benzene the molecular weight of the alcohol, calculated from the freezing-point of the solution, corresponds to the formula $4{\cdot}83\ C_2H_5(OH)$. When water is added to this solution the freezing-point rises in proportion to the quantity of water added, the elevation being very nearly that which would be expected if the water added combined with the alcohol to form the hydrate $9C_2H_5(OH)+3H_2O$. When about 11·5 % of water has been added, the solution becomes non-homogeneous and the freezing-point rises more slowly than before. Similar results were obtained with solutions of phenol and acetic acid in benzene; in the latter case the solution becomes turbid after the addition of one or two drops of water. Substances such as glycerol or lactic acid give results similar to those observed with water. T. E.

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672. *Electrolytic Conductivity of Salts in Pyridine.* **St. v. Laszczynski** and **St. v. Gorski.** (Zeitschr. Elektrochem. 4. pp. 290–293, 1897.)—The conductivity of KI, NaI, NH_4I, LiCl, KCNS, NaCNS, and NH_4CNS are determined in solution in pyridine. The first three and the last converge to a limit of 40 to 45 for the molecular conductivity at infinite dilution at 18° C. LiCl is very slightly dissociated, which the author connects with the fact that it forms a compound, $LiCl+2C_5H_5N$. Attempts to obtain the alkali-metals by electrolysis in pyridine succeed only in the case of lithium. The following salts did not conduct in pyridine—$MgCl_2$, $CeCl_2$, $CaCl_2$, $CoCl_2$, and AgI. B. B. T.

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673. *Electrochemical Theory.* Part II. **R. Mewes.** (Elektrochem. Zeitschr. 4. pp. 167–173, 1897.)—An account, from an historical and philosophical standpoint, of some points in chemical theory. Atomic weights, atomic volumes, heats of combustion, and the unity of the chemical elements are here discussed. J. W.

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674. *Electrolytic Production of Iodoform.* **F. Foerster** and **W. Mewes.** (Zeitschr. Elektrochem. 4. pp. 268–272, 1897.)—A patent for the production of iodoform by electrolysis of an alcoholic solution of potassium iodide was obtained by Schering in 1884;

and a short time ago, at the instigation of one of the present authors, the reaction was investigated by Neubert. He showed that it was necessary to add a certain amount of alkaline carbonate, and to raise the temperature to about 60°. The passage of a stream of carbon dioxide through the electrolyte was also found to be indispensable. The subject has recently been investigated by Elbs and Herz, whose results agree in the main with those of Neubert, but they state the use of carbon dioxide to be unnecessary. It was to explain this discrepancy that the present work was undertaken. The authors agree with Elbs and Herz in representing the formation of iodoform by the equation

$$C_2H_6O + 5\,I_2 + H_2O = CHI_3 + CO_2 + 7\,HI.$$

Their experimental conditions differ from those obtaining in the work of Elbs and Herz chiefly in that the use of a porous cell is avoided and the kathode simply enveloped in parchment-paper. Not only is the resistance thus greatly diminished, but the alkali formed at the kathode easily mixes with the fluid round the anode, and prevents the formation of free acid. Now the above equation shows that for every 10 equivalents of iodine separated at the anode only 7 equivalents of acid are produced, while 10 equivalents of free alkali are formed at the kathode; and, since free alkali is prejudicial to the production of iodoform, a stream of carbonic acid is therefore required to convert the excess into carbonate. If, on the other hand, a porous cell is used, the fluids mix much more slowly, and there is a tendency to the production of free acid at the anode: in this case, therefore, carbonic acid is unnecessary, and addition of alkali is rather required. The discrepancy between different observers is thus simply due to the difference in the experimental conditions, and emphasises the importance of strict attention to the latter in electrolytic work. In this instance the object to be attained in all cases is the maintenance of a certain slight alkalinity at the anode. J. W.

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675. *Electrolysis of Aqueous Solutions.* **L. Glaser.** (Zeitschr. Elektrochem. 4. pp. 355–358, 373–379, 397–402, 424–428, 1898.) —The paper is divided into three parts. Part I. deals with the experimental determination of the E.M.F. of the hydrogen-oxygen couple (1·08 volt) and its temperature-coefficient (0·00143); and on the influence of the concentration of the electrolytes, of other solvents than water, and of hydrogen peroxide. The measurements fully confirm the conclusion previously arrived at by Smale that the formation of water in the gas-couple is a reversible process.

Part II. treats of the decomposition of water. The effect of an E.M.F. ranging from 0 to 1·67 volt on solutions of acids was studied, and the observed deflections of the galvanometer plotted against the E.M.F.'s; the curve shows a distinct break at 1·08 volt, the value obtained for the O-H couple. It is therefore permissible to speak of a two-fold point of decomposition of water, at 1·08 volt and at 1·67 volt. In the former case, the O and H ions are of course doubly charged; they exist in the solution in relatively small numbers, and hence the point of decomposition is ill-marked and easily overlooked. On the other hand, at the E.M.F. of 1·67 volt, H and OH ions are separated in comparatively large numbers: the latter of course undergo a secondary reaction of the anode.

In Part III. the points of decomposition of the dissolved electrolytes are dealt with, and the conclusion arrived at is that the decomposition of water, even if it can be brought about primarily to a great extent, is in reality accomplished principally in a secondary manner. J. W.

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676. *Electrolytic Preparation of Perchloric Acid and its Salts.* **F. Foerster.** (Zeitschr. Elektrochem. 4. pp. 386–388, 1898.)—The fact that chlorates when electrolysed in neutral or acid solution are oxidised to perchlorates at the anode was noticed by Stadion in 1816, and again in 1847 by Kolbe. The author now studies the influence of concentration, temperature, and current-density on the course of the reaction, which is shown to be capable of development into a simple and practical process. The best results are obtained by the use of concentrated solutions and a fairly high current-density; a rise of temperature greatly diminishes the yield. Owing to the sparing solubility of potassium chlorate at ordinary temperatures, it is best to electrolyse a solution of sodium chlorate, and obtain the potassium salt by double decomposition with potassium chloride. This conversion of chlorates into perchlorates proceeds equally well in acid solutions. With alkalies, however, the oxidising action of the current is only observed at the commencement of electrolysis, and it is even then inconsiderable, and very soon ceases altogether. From this it appears that the immediate conversion of chlorides into perchlorates is impracticable, since chlorates, the intermediate product, alone are obtained by electrolysis in alkaline solutions. J. W.

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677. *Electrolytic Iron.* **F. Haber.** (Zeitschr. Elektrochem. 4. pp. 410–413, 1898.)—This is a description of the iron stereotype-plates from which the notes of the Austro-Hungarian bank are printed. The metal is precipitated by a very feeble current from a solution of ferrous and magnesium sulphates. It contains about twelve times its volume of hydrogen, and this peculiarity is discussed at length. J. W.

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678. *Electrolytic Reduction of the Nitro Group.* **W. Löb.** (Zeitschr. Elektrochem. 4. pp. 428–437, 1898.)—This paper deals with the chemical nature of the substances obtained by the electro

lytic reduction under various conditions of nitrobenzene and paranitrotoluene. J. W.

679. *Electrolytic Separation of Cadmium and Zinc, Zinc and Cobalt, and Antimony and Tin.* **A. Waller.** (Zeitschr. Elektrochem. 4. pp. 241–247, 1897.)—The author discusses the merits of the processes which have been proposed by previous observers, whose experiments he has in many cases repeated and extended. The following methods are stated to be the best, the separation depending in each case on the E.M.F. in the electrolytic cell being sufficient to cause the decomposition of the salt of the one metal, whilst insufficient for that of the other.

Cadmium and Zinc. The solution of the chlorides of the metals is mixed with potassium and ammonium oxalates. The temperature should be at about 80–85°, and the E.M.F. not more than 0·3 volt above that required for the decomposition of the cadmium salt.

Zinc and Cobalt. The sulphates are dissolved in water containing some Rochelle salt, caustic soda, and a little potassium iodide. The temperature is kept at 60–65°, and the E.M.F. at about 2 volts. The use of potassium iodide diminishes, but does not entirely prevent, the deposition of a small amount of cobaltic oxide on the anode. The latter is therefore weighed before and after the electrolysis, and a suitable correction made.

Antimony and Tin. The salts of the metals are dissolved in perfectly pure sodium sulphide solution to which a little caustic soda is added. The temperature is conveniently kept at about 65°, and the E.M.F. should not exceed 0·7 volt. J. W.

680. *Electrolytic Separation of Cadmium and Iron.* **W. Stortenbeker.** (Zeitschr. Elektrochem. 4. pp. 409–410, 1898.)—The mixed salts of the metals are dissolved in water faintly acidified with sulphuric acid, 2 or 3 grams of pure potassium cyanide added, and the mixture heated until a clear yellow solution is obtained. This is electrolysed in the cold, using a weak current of 0·05 to 0·1 ampere. If much ferric salt is present it is reduced with sodium bisulphite. The best analyses given are very satisfactory.

J. W.

681. *Thermic Equilibrium in Electrolysis.* **D. Tommasi.** (Elect. Rev. 42. p. 61, 1898.)—The author considers how a compound which is capable of both oxidation and reduction will behave when subjected to oxygen and hydrogen by electrolysis, and concludes that the reaction that evolves most heat will take place, provided that it can begin. Further, the reaction that requires least heat to begin will take place in preference to the other. W. R. C.

682. *Carbon Electrode with Multiple Copper Leads.* **K. W. Hertel.** (Elektrochem. Zeitschr. 4. pp. 174–175, 1897.)—The electrode consists of a block of gas-carbon of any suitable form, provided with a number of apertures holding a copper fitting in immediate contact with the carbon. The apertures in the fitting are filled with copper oxide or manganese dioxide, in which the copper leads are immersed; the other ends of the leads are connected by a metal strap. A diagram is given. J. W.

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683. *Electrolysis in Gold Extraction.* **E. Andreoli.** (Elektrochem. Zeitschr. 4. pp. 149–155, 1897.)—The merits of the electrolytic and zinc-precipitation processes for the extraction of gold from cyanide solution are discussed, and preference given to the former. A larger outlay is required for the plant, but the cost per ton of material treated is one-sixth less than in the zinc process. The writer advocates the use of lead peroxide plates at the anode, the gold being deposited on iron kathodes. The latter are finally immersed in a bath of molten lead, to dissolve the gold, and are then ready for further use. J. W.

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684. *Electrolytic Gold-Refining.* **E. Wohlwill.** (Zeitschr. Elektrochem. 4. pp. 379–385, 402–408, 421–423, 1898.)—A number of observations arising from the practice of electrolytic gold-refining, which the author suggests may be of value in affording confirmations and proofs of various electrochemical facts and theories. The paper is unsuited for abstraction. J. W.

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685. *Electrolytic Bleaching of Cotton.* **H. Wartner.** (Elektrochem. Zeitschr. 4. pp. 261–263, 1898.)—A solution of rock-salt is electrolysed with the formation chiefly of hypochlorites, and the liquid is stored in closed vessels for use when required. Under certain conditions of working, the process is cheaper than the use of bleaching-powder in the ordinary way, and is already successfully carried on in various parts of Germany. The cost of the plant required is dealt with. J. W.

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686. *Electrolytic Zinc: the Hoepfner Vat.* (Indus. & Iron, 24. p. 208, 1898.)—This is a short description, illustrated with five figures, of the recently patented Hoepfner apparatus and process for recovering zinc from zinc-chloride solutions. A V-shaped trough is divided transversely by means of diaphragms into an equal number of anode and kathode compartments. In the former, flat carbon anodes are fixed in suitable frames, while circular zinc or iron plates mounted upon a central shaft running the length of the vat function as kathodes and revolve with their

lower halves immersed in the electrolyte contained in the kathode compartments.

The construction details by which the framework of the vat is made with channels to provide the necessary supply and circulation of the zinc-chloride solution are also described, and form part of the Patent claim. The design of the vat is such, that when necessary it may be suspended from girders, and a bottom support be dispensed with. J. B. C. K.

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687. *Zinc Extraction by the Ashcroft Process.* **R. Threlfall.** (Elektrochem. Zeitschr. 4. pp. 189–196, 1897.)—This is a lengthy illustrated article dealing with the chemistry of this electrolytic extraction process, and describing the plant erected at Cockle Creek, New South Wales. The process has been often described in the English Technical Journals (see 'Cantor Lectures,' 1896, Swinburne); and the only new feature introduced is that the solution of zinc used in the kathode chambers is made basic, either by the addition of zinc oxide or of an alkaline hydrate. The patentee considers that better results are obtained from such solutions than from neutral or acid solutions.

The plant at Cockle Creek was erected, but was not in operation at the date of writing. The generating plant consists of 5 Babcock boilers, which supply steam to 5 Willans high-speed engines, direct-coupled to 5 Siemens dynamos. The smaller dynamos deliver 1100 amperes at 120 volts pressure, the larger ones double this amount. Each unit of generating machinery has its own switch-board. The vat-shed is 175 × 100 feet. The vats are raised upon iron supports about 5 feet above the ground, and each vat is connected by caoutchouc tubing to the lead supply-pipes. The material of the vats is Californian redwood; they are each 6 × 6 × 6 feet, and each is divided into four compartments by means of canvas and wood. Each of these compartments contains 12 kathodes and 13 anodes, 4 feet long by 1 foot broad. This small size has been chosen, in order that the anodes may be easily handled by the workmen. The anodes are of carbon and of iron; the kathodes are of rolled zinc $\frac{1}{25}''$ thick. The electrodes in each vat are worked in parallel, the vats in series. The E.M.F. per vat varies from 1 to 2·8 volts, according as iron or carbon is used as anode material. Each electrical circuit contains 48 vats with iron anodes and 24 with carbon anodes; these 72 vats demand 120 volts when worked in series. Figures are given in the original article to elucidate the arrangement of the electrodes and the plan of current distribution. A current-density of about 5 amperes per sq. foot is used, and the area of the kathode-surface in a double vat (12′ × 6′ × 6′) suffices to allow a current of 5000 amperes to pass through the system.

The author considers that Ashcroft's views concerning the character of the deposits obtained from basic zinc solutions require further confirmation. He states that the current-density used is not of importance, if the solutions be of the right constitution and concentration to give dense metallic deposits of zinc. Under these conditions either 2 or 100 amperes per sq. foot may be employed. The variation in the physical character of the zinc deposits that are obtained from solutions which, from the chemical point of view, are similar in every respect, he attributes to the presence of minute quantities of unrecognised elements in the solution. The detection of these, and study of their influence, he considers the technical electro-chemical problem of the present time. J. B. C. K.

688. *Electrolytic Pickling.* **S. Cowper-Coles.** (Elect. Rev. 42. p. 63, 1898.)—A vat is described for this purpose. Any scale that becomes detached may be collected magnetically in the acid electrolyte, if this is caused to flow past electromagnets. W. R. C.

GENERAL ELECTRICAL ENGINEERING.

689. *Variation of E.M.F. and Efficiency of Lead Accumulators with Strength of Acid.* **F. Dolezalek.** (Zeitschr. Elektrochem. 4. pp. 349–355, 1898.)—It is contended that the theory of Liebenow, which regards the accumulator as a reversible cell, is the only one which can be consistently maintained, and with which the behaviour of the cell is in agreement. The differences in the E.M.F. of accumulators with different concentrations of acid are shown to be in excellent accordance with the values calculated by two independent methods based upon thermodynamical considerations. The efficiency of the accumulator amounts on the average to 75–85 °/₀, although 94–97 °/₀ of the current used in charging is recovered on discharging. This is caused by the difference in E.M.F. during charging and discharging, which has led to the belief that the action is only partially reversible. This difference is attributed to mechanical hindrances to the equalisation of acid concentration in the neighbourhood of the electrodes, whereby the accumulator behaves during charging as if filled with a stronger acid, and during discharge as if filled with a weaker acid, than is really the case. It is calculated that the accumulator should work with maximum efficiency when filled with acid of maximum conductivity (30·4 °/₀ H_2SO_4). Here also experiment is in close agreement with theory. J. W.

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690. *Storage Batteries.* **E. J. Wade.** (Electrician, 40. pp. 350–351, 444–446, 591–593, & 757–759, 1898.)—A series of articles dealing with the construction of storage batteries. W. R. C.

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691. *Accumulator Construction.* **D. Fitz-Gerald.** (Elect. Engin. 21. pp. 14–15, 39–41, 72–74, 103–105, 136–137, 170–172, 199–202, 230–231, 262–263, 299–301, 328–330, 393–395, & 518–519, 1898.)—A series of articles dealing with the construction of storage batteries. W. R. C.

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692. *Kelvin's Instruments.* **M. Maclean.** (Elect. Engin. 21. pp. 231–233, 301–303, 337–339, 358–359, 390–393, & 421–423, 1898.)—An abstract of a paper read before the Philosophical Society of Glasgow, and descriptive of Kelvin's well-known electrical instruments. W. R. C.

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693. *Temperature Coefficient of Thomson Meter.* **W. L. Hooper.** (Elect. World, 31. p. 384, 1898.)—The author refers to the work of G. W. D. Ricks on this subject, who obtained the value $-0{\cdot}0032$ for the coefficient (Elect. World, 9. p. 248, 1897),

and describes the methods and apparatus used by himself in testing four Thomson meters of American manufacture. Experiments were made at temperatures between 0° C. and 44° C. with various loads, giving a mean value for the coefficient of $-0{\cdot}00048$. The results are not very concordant, ranging between $-0{\cdot}00030$ and $-0{\cdot}00060$; the author accounts for this on the ground that a small error in determining the constant of the meter causes a very large error in the value of the coefficient. The author concludes that a greater error than 1 per cent. in the record of the meter is not likely to occur in practice, and suggests a possible explanation for the high value obtained by Ricks. A. H. A.

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694. *Water Rheostats.* (Electrician, 40. pp. 696–697, 1898.)—Water rheostats may be used where a non-inductive load is required to absorb a large amount of electrical power. If the voltage is less than 1000, the conductivity of the water should be increased by the addition of a solution of sodium sulphate. In some tests of a 450-kilowatt 500-volt three-phase plant at Bakersfield water rheostats were used. They consisted of three separate redwood tanks, each measuring 4 ft. by 4 ft. by 6 ft., and each containing two sheet-iron electrodes of such size as to give 5 in. in the clear when suspended in the tanks. Three of the six electrodes, one from each tank, were coupled together in short circuit, while the three legs from the three-phase generator were each taken to the remaining electrode of its respective tank. Each phase was thus provided with a rheostat capable of absorbing 150 kilowatts. The amount of sulphate of soda was so regulated that the rheostats would carry a load of 500 H.P. for three hours without boiling. In order to keep the temperature low, and to wash off the bubbles of oxygen and hydrogen from the electrodes, it is advisable when high voltages are used to keep a constant circulation of water through the tank. W. G. R.

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695. 200-*Volt Lamps and Apparatus.* **G. Binswanger-Byng.** (Electrician, 40. pp. 654–657, 685–689, 1898.)—The author discusses mainly the modifications which have been rendered necessary in incandescent lamps, arc lamps, switches, cut-outs, and other fittings, to adapt them for use on 200-volt circuits.

Incandescent Lamps.—In order to reduce the length of the filament required so as to enable it to be arranged within the same size bulbs as are used for 100-volt lamps, the makers have employed unflashed filaments which have a higher specific resistance. The C.P. and efficiency, however, fall off more rapidly than with flashed filaments. Some tests showed that in the average unflashed 200-volt 16-c.p. lamp, the percentage loss of candle-power in 600 hours is about 42 %, and the average drop in efficiency is about 35 %, the surface of the filament becoming dull, sooty, and often full of small pit-holes. Robertson finds that carbon of lower specific resistance (flashed) is less volatile than unflashed carbon, and therefore better retains its original candle-power and efficiency whilst being mechanically stronger. The average specific resistance of 200-volt unflashed lamp carbon is 3500–5000 microhms per c.c., whilst flashed carbon is easily obtained of 2400 microhms per c.c. The author therefore prefers to use flashed filaments, employing a bulb of slightly larger size. He advocates the use of a non-metallic cap and a lamp having a single filament arranged so as to withstand the disturbing effects of gravity and electrostatic charges on the bulb.

Switches, Cut-outs, etc.—Drawings are given of several types of switch, ceiling-rose, wall-plug, lamp-holder for use on 200-volt circuits, and also of a new form of cut-out, the principal feature of which is the employment of a *fuse-chamber*, *i. e.*, a round china wall forming a central hole from ½″ to 1″ diameter, and pierced with two holes near the terminals which are fixed on the base outside. The fuse-wire is threaded through diametrically-opposite holes in the fuse-chamber which is lined with plaster-of-Paris, this material not being liable to volatilise and feed the arc. Fuse-wires enclosed in glass tubes filled with plaster or cement, but with a free central space for fusion, are also satisfactory.

Arc Lamps.—Since, for economical working, it is necessary to work with four or five lamps in series, there is a danger of burning out the shunt coils of some of the lamps, if the carbons of one or more of the lamps should be short-circuited. The author proposes to protect the shunt-coils by means of temperature-fuses, or by an automatic cut-out and cut-in whereby the arc is first short-circuited through a shunt-path; this short-circuit is then broken by a quick-break switch, the same action reversing the shunt-switch simultaneously, ready to fall upon its normal contact when the carbons touch, or are replenished. This mechanism is actuated by the main armature of the lamp, these movements taking place when the armature is below the feeding-point.

In the discussion which followed this paper, **H. L. P. Boot** stated that there was less risk of explosions with fuses when using alternating currents than there was with direct currents. **C. H. Stearn** considered that, for the present transitional period, untreated filaments were the best, since they could be easily produced of greater uniformity than treated filaments. Treating, to be reliable, must be thick, and if properly treated a 16-c.p. 230-volt lamp would need a length of filament of 14″ to 15″. This should be bent backwards and forwards so that the whole length could be enclosed in a small compass and used in bulbs of the old size. He did not consider it necessary to put the filaments further apart. He considered it possible to use filaments containing boron, silicon, alumina, etc., and had seen some which contained at least one of these substances and did not show any material change in efficiency for 300 hours working at 2·8 watts per candle. **J. Swinburne** found that untreated filaments lasted better than treated ones; he, however, always flashed them *in vacuo*. **C. H. Wordingham,** in connection with supply at 200 volts, has specified that the length of break in switches and fuses must be such as to permit a 50 °/₀ excess of current at a 50 °/₀ excess of pressure without arcing. With regard to cut-outs, he had specified that they must be capable of breaking a short-circuit with a fuse-wire in the cut-out. **H. W. Miller** stated that combination-filaments could be made to work at 2½ watts so as to give as good results in c.p. and efficiency as a carbon filament working at 3½ watts. He found that a satisfactory way of changing small fan-motors from 100 to 200 volts was to put the shunt-winding in series with the armature. **C. J. Robertson** preferred flashed filaments, and stated that lamps lasted better with alternating than with direct currents. He found that wavy-filament lamps were not suitable for horizontal burning unless supported, or made with unflashed carbons. **S. P. Thompson** preferred low voltages, and considered that improvements in incandescent lamps should lie in the direction of improving the carbon of the filaments. **J. W. Swan** considered that untreated carbon was still open to much improvement. **R. E. B. Crompton** said that arc-lamps had been run for years at Liverpool Street Station four in series on 200 volts, and that the number of shunts burnt-out had not amounted to 1 °/₀ per annum, although no such cut-outs were in use as were mentioned by the author. C. K. F.

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696. *Lightning-Protector.* **M. Aliamet.** (Électricien, 15. pp. 69–71, 1898.)—This apparatus, which is constructed by the Western Electric Co., and has been in use for several years in America for telephones, consists of a base having at one end two lateral terminals for the attachment of the line wires, and one in the centre for the earth-connection, and at the other end two lateral terminals for the telephone connections. The lateral terminals on each side are connected by a fuse arranged in series with a ferro-nickel resistance-coil of 27 ohms, and surrounded by an asbestos tube, the whole being mounted in a tube of vulcanised fibre provided with a terminal at each end. The point of junction between the coil and the fuse-wire is connected to a metal ring on the exterior of the fibre tube; this ring fits between metal springs on the base, which are each connected to one of a pair of contact-springs arranged in the centre of the board and having a central plate between them, which plate is connected to the "earth" terminal. Between each of these springs and the central plate is slid a lightning protector, consisting of two carbon plates separated by a sheet of mica having a hole in it. In one of the carbon plates is a recess registering with this hole, and containing a bead of fusible metal, so that, when sparks play through the hole in the mica, the metal will melt and short-circuit the carbon plates. If the discharge is insufficient to actuate the lightning-protector, it melts the fusible wire and thus interrupts the telephone circuit. If the discharge-current is too weak to fuse this wire, but is still of sufficient strength to be dangerous, it causes the circuit to be interrupted as follows, viz.:—The connection between the resistance-

coil and the fuse-wire is made through a strip of fusible metal which is thermally connected to the resistance-coil by means of a metallic bobbin on which this coil is wound. Against this metal strip the end of a glass rod is pressed by means of a spring, so that when the resistance-coil heats the fusible strip, the glass rod is forced through the said strip by the spring and breaks the circuit. C. K. F.

697. *Carbons for Electric Lighting and other Purposes.* **F. Jehl.** (Electrician, 40. pp. 476–478, 593–595, 797–799, and 826–827, 1898.)—A series of articles relating to the manufacture of carbons. W. R. C.

698. *Electric Machine Tools.* (Mech. Eng. 1. pp. 149–151, 1898.)—Adamson's, of Hyde, find utility not so much in the coal economy as in saving labour, absence of belt-slip enabling machines at heavy loads to maintain their full speed. Air and water under pressure are not discarded. A description is given of Perrett's furnace, in which the fire-bars are under water; also of a boiler-flanging press (hydraulic), plate-bending rolls (electric), and punching machine (electric). A boring machine up to 2′ × 2′ takes 17 amps. at 110 volts. Good figures are given of a hydraulic rivetter fed by an electric winch, a semi-portable drill, and a 10-cwt. electric crane supplied to the Royal Mint. M. O'G.

699. *Electrical Travelling Cranes.* (Mech. Eng. 1. pp. 196–198, 1898.)—Adamson's, of Hyde, obtain the following results with three motors to each crane:—

Lifting capacity, in tons	30	10	5
Speed, in ft. per min.	2·4	6·3	13·1
H.P. absorbed, full load	9	9·6	10·4
Efficiency, per cent.	54·35	56·3	46·9
Speed down shop, ft. per min. ..	80	100	160
H.P. absorbed in ditto	5	3·3	2·8
Speed traversing shop, ft. per min.	20	40·6	59·3
H.P. absorbed	3·1	1·35	0·85

The increased power in smaller cranes is due to increased speed of lifting. It is found that ropes for these cranes formerly took 5 H.P. per 100 ft., or in Adamson's shop 12 H.P. continuously wasted. Spur- or worm-gear are used for motor reduction. The travelling wheels are cast in one with the spur-wheels. The main axle is lubricated by a roller of wood floating in oil, by which means the lubricant is applied on what experiment proves to be the right place—where there is no pressure. M. O'G.

700. *Electricity in Factories.* **C. H. Benjamin.** (Mech. Eng. 1. pp. 98–99, 1898.)—Electric cranes and the rearrangement of

machines allowed by electric driving has, in the Baldwin Locomotive Works, reduced 40 labourers to 10, and the skilled time lost from 10 % to 2 %. The absence of the dust and shadows cast by belts is remarkable. M. O'G.

701. *Electricity on Board Ship.* **E. G. Tidd.** (Elect. Engin. 21. pp. 435–439 & 454–459, 1898.)—A fairly detailed description of plant, and applications of electricity on board ship. W. R. C.

702. *Electricity in Mining Operations.* **F. A. C. Perrine.** (West. Electn. 22. p. 157, 1898.)—This article points out that the application of electrical power for mining purposes is at present defective, chiefly because electricians are not acquainted with the miners' requirements and miners themselves are usually ignorant of the principles underlying electrical engineering. The electric drills are defective, and cannot take the place of the pneumatic drill. Cables are not made suitable for mines, since they are usually too heavily insulated for vertical shafts, and lead-covering is attacked by acidulated water. Although electric elevators are successful for office and factory purposes, the application of the electric motor to hoisting when the power is derived from a long distance is not successful, especially when the hoist is required to stop and start frequently and has to run at different speeds. One of the most important of the applications of electricity to mining is electrolytic deposition; yet only the simplest cases can be thus dealt with. The application to the recovery of metals from leached liquors has not yet been investigated. W. G. R.

703. *Edison's Magnetic Concentration Works.* (Elect. Rev. 42. pp. 188–191, 1898.)—An account is given of the method used in the magnetic concentration of low-grade iron ores in New Jersey, and of the preliminary treatment necessary. The actual amount of handling is very small. The excavation is effected by means of a 60-ton or a 93-ton shovel. A large number of rolls, the largest being 70 tons in weight, are used for crushing the ore. After screening through 14-mesh screens, the first magnetic separation is carried out by allowing the powdered ore to fall in a vertical stream past the electromagnets. Further concentration and screening is carried out; and finally the concentrated ore is made up into briquettes containing about 68 % of iron. This is necessary, as the blast furnaces cannot deal with powdered ore. The plant is capable of mining 5000 tons in 20 hours. W. R. C.

704. *The "Little" Integrating Indicator.* (Electrician, 40. pp. 787–788, 1898.)—The purpose of this instrument is to obtain a numerical index of the work done by the engine in any given number of revolutions. The pulsations of steam-pressure in the indicator cylinder are caused to vary the angle

the integrator disc makes with the axis of a barrel against which it is lightly pressed, and which is oscillated by means of a cord from the engine crosshead. If the time it is in operation and the number of revolutions made by the engine be noted, either the mean H.P. or the total work done can readily be found. A. S.

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705. *New Governor for Hydraulic Motors.* **E. H. Rieter.** (Électricien, 15. pp. 145–152, 1898.)—In this apparatus any excess of energy above that required for the normal speed of the motor is absorbed by an electric brake. A mass of iron is rotated in a magnetic field, and consequently becomes heated by the Foucault currents generated; the heat is dissipated by providing efficient circulation of air. The exciting current, and therefore the work absorbed by the brake, is controlled by a centrifugal governor and rheostat, the latter having a number of points which may make contact with a bath of mercury. In many cases the speed-variation has been less than one per cent. for a sudden variation of 50 per cent. of the normal load. A. S.

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706. *Breakdowns from Priming.* (Elect. Rev. 42. pp. 356–357, 1898.)—Three Willans engines having been wrecked by sudden and excessive priming of one or more water-tube boilers, this paper discusses the use of separators and the arrangement of steam-piping with the view of supplying fairly dry steam to the engine. A. S.

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707. *Mechanical Stokers at Carnegie Steel Works.* (Elect. Rev. N.Y. 32. p. 133, 1898.)—The steam-generating plant recently installed at the Carnegie Steel Works, Pittsburgh, consists of a battery of 24 two-flue boilers, each 54 ins. diameter by 28 feet long, and is perhaps the largest and most complete plant of the kind. Each boiler develops 178 H.P., and the "American" mechanical stoker is used, one fireman attending to eight boilers. Using the cheapest grade of soft coal, hardly a trace of smoke is seen at the chimney-top. A. S.

DYNAMOS, MOTORS, AND TRANSFORMERS.

708. *Commutation in Dynamos and Motors.* **W. H. Everett** and **A. H. Peake.** (Electrician, 40. pp. 861–862, 1898.)—The object in view was to examine experimentally the reversal of the current in a "section" of the armature-winding while passing under either brush. A special split brush was used, consisting of two copper plates separated by vulcanised fibre. These plates were joined by a non-inductive resistance of 0·007 ohm, to the middle of which one main was connected. The resistance of an armature-section was 0·008; the machine was bipolar, with smooth-core ring armature wound with 60 sections, to give 45 amperes at 110 volts. The instantaneous P.D. across the non-inductive resistance, and hence the current of the coil under the brush, was found by charging a condenser, joined to the ends of the resistance, through a revolving contact-maker, and then discharging through a ballistic galvgnometer. By altering the position of the contact-maker, the current was found for different positions of the coil under the brush. The brushes were adjusted to avoid sparking. With the machine used as a motor, the current was found to reverse quickly, in a typical case, to about half its final negative value; it then diminished slowly, and finally rose again quickly. The final change is presumably due to decrease of contact-surface between brush and commutator-segment. A weaker field gives a more gradual reversal. Change of speed has little effect. With a smaller backward lead, a larger part of the reversal has to be effected at the last. With the machine used as a dynamo, the reversal is more nearly uniform throughout; but there may be excessive reversal, requiring a final *diminution* of the current by contact-resistance. And in some cases the current may *rise* at first. These results are such as we should expect. In a dynamo, the field for reversal lies in front of the neutral axis, and in a motor, behind it. Hence in a dynamo the brush must be in such a position that the neutral axis is near (or beyond) the heel, and in a motor near the toe. This explains the results. Further experiments are proposed. AUTHORS.

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709. *Patin Fly-Wheel Alternator.* (Engineer, 85. pp. 263–264, 1898.)—This is an illustrated description of a fly-wheel alternator made by Messrs. Patin & Co. In this machine the magnetic field forms an integral part of the driving-engine. The fly-wheel of the engine carries the field-magnets of the dynamo, and the armature is stationary but is capable of being slid out of the magnetic field by a lateral movement, thus permitting the coils to be revarnished when necessary. Details of two alternators of this type are given below. No. 1 was coupled direct to a turbine, and No. 2 to a steam-engine.

	No. 1.	No. 2.
Power produced, in watts	40,000	120,000
Voltage	2,400	2,400
Resistance of armature, in ohms	4·5	0·96
Number of coils on magnets	24	104
Resistance of magnets, in ohms	4·8	2·5
Revolutions per minute	300	95
Efficiency, per cent.	94	96
Power used for exciting (watts)	1,200	2,400

From these machines 12 lamps of 16 candle-power can be fed per horse-power developed. W. G. R.

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710. *Alternating-Current Motors.* **E. E. Tasker.** (Elect. Engin. 21. pp. 403–407 & 427–428, 1898.)—A paper read at a students' meeting of the Institution of Electrical Engineers. It deals generally with the theory and working of alternate-current motors. W. R. C.

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711. *Single-Phase Motors.* **A. C. Eborall.** (Elect. Rev. 42. pp. 432–433 & 500–502, 1898.)—These conclude a series of articles by the author on single-phase motors (see Abstract No. 444). Fig. 1 shows the efficiency, power-factor, and percentage drop of speed of a 3-H.P. six-pole motor, constructed by Messrs. Brown, Boveri & Co., running at 100 volts and a frequency of 100 alternations per second. Fig. 2 gives the results of a test of a 2-H.P. Kolben motor, designed to run at 1500 revolutions per minute on a 110-volt circuit and at a frequency of 50 complete cycles per second. The curve AA

Fig. 1.

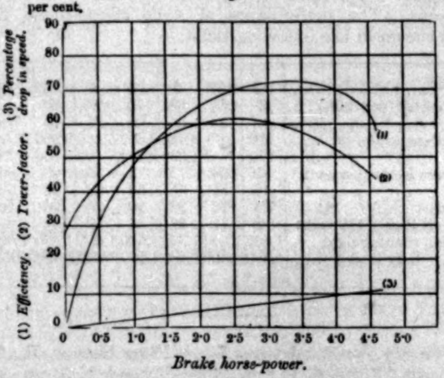
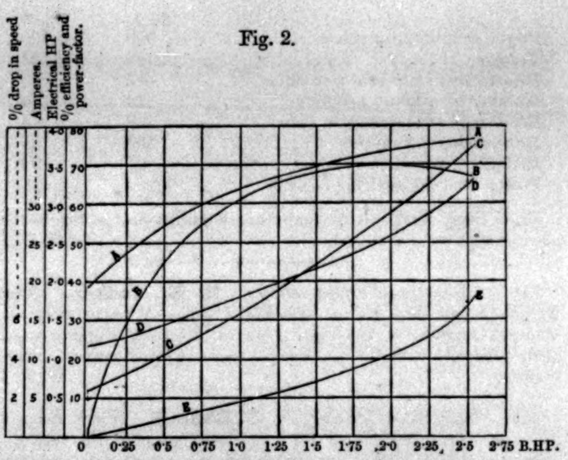


Fig. 2.



gives the power-factor, BB the efficiency, CC the power absorbed, DD the amperes at 110 volts, and the curve EE gives the percentage drop in speed. In the Kolben motors leakage is minimised by the magnetic separation of the stator core discs from the containing case. The performance of some single-phase Kolben motors is shown in the following table:—

Horse-power		0·2	0·75	2	3·5	6	10	15	20
Full-load efficiency (per cent.)		55	64	68	72	76	80	82	83
Half " " "		42	53	56	60	65	69	72	73
Full-load watt-consumption		270	860	2,160	3,600	5,800	9,200	13,500	17,800
Half " " "		170	520	1,300	2,150	3,400	5,700	7,700	10,000
Full-load power-factor (per cent.)		65	68	72	73	75	80	80	82
Half " " "		48	51	55	56	60	62	62	64
Amperes at start	At 110 volts.	7·5	18	38	50	65	90	120	145
" full load		3·8	11	27	45	70	105	154	200
Revs. per min., running light		1,500	1,500	1,500	1,500	1,500	1,500	1,000	1,000
" " fully loaded		1,350	1,390	1,400	1,430	1,430	1,430	965	965

W. G. R.

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712. *Starting Non-Synchronous Single-Phase Motors.* **R. Arno.** (L'Elettricista, Rome, 6. 11. pp. 265–269, and 7. 5. pp. 97–98, 1898.)—The author shows that, with a suitable resistance in the armature circuit, a single-phase motor can be started by giving a very small initial velocity to the armature, such in fact as can be given by a pull on the belt by hand. Once started, the resistance can be gradually cut out. This method of starting does away with the necessity of two windings on the inductor and means for

producing a difference of phase between the two (see Abstract No. 77).

The author, in his second paper, describes a method of giving the initial starting-pull to the motor by electrical means only. The method is to produce a dissymmetry in the armature at the moment of starting by opening the circuit of one of its windings. Then, provided the armature is not at a dead-point, it will rotate through a portion of a turn, and, if the circuit be then closed, this rotation provides a sufficient impulse to enable the motor to get up speed. Supposing the armature to have a three-phase winding, a three-arm resistance-switch is inserted in the three circuits, the full resistance being the best starting resistance mentioned above. Two circuits are closed through the resistances; the third is brought to one pole of a two-pole switch, the other pole of which is in the field circuit. The switch is so arranged as to first close only the field circuit, thus giving an initial rotation to the armature; a further movement of the switch closes the armature circuit and enables the motor to get up speed. The best conditions for starting are obtained by cutting all outside resistance out of the armature circuit, putting it in immediately the circuits are closed. The armature can be moved from a position of dead-point by means of a switch in one of the other circuits; if the double-pole switch be closed, leaving this switch open, the armature will rotate to a dead-point corresponding to this position of dissymmetry. On breaking the circuit and closing the single-pole switch, the position of dissymmetry is changed, and the motor is no longer at a dead-point. The direction in which the motor starts is determined by the circuit in which the single-pole switch is placed.

G. H. Ba.

713. *Separation of Iron Losses of a Transformer.* **H. S. Carhart.** (Elect. World, 31. p. 306, 1898.)—If the frequency of the voltage applied between the primary terminals of a transformer is varied while the induction in the core is kept constant, then the total iron losses W_1 may be written

$$W_1 = an_1^2 + bn_1, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where a and b are constants and n_1 is the frequency.

If the frequency is changed to n_2, we get

$$W_2 = an_2^2 + bn_2. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Solving equations (1) and (2) we get the values of a and b, which are respectively the eddy-current loss and hysteresis loss per cycle for the same maximum induction. W_1 and W_2 are determined by taking wattmeter readings on open secondary circuit.

The author applies this method to an actual case, and also calculates the value of the exponent k in Steinmetz's formula

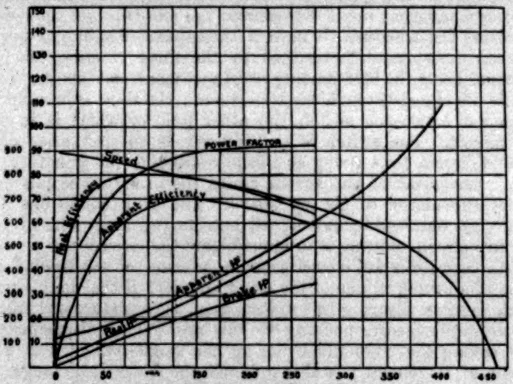
$$W = \eta n B^k$$

for hysteresis loss.

W. G. R.

714. *Practical Operation of Multiphase Currents.* **T. Hawkins.** (Elect. Rev. 42. pp. 421–422, 456–457, & 489–490, 1898.)—This is a paper read before the Northern Society of Electrical Engineers. The chief features of interest are the illustrations and curves, two of which are here reproduced.

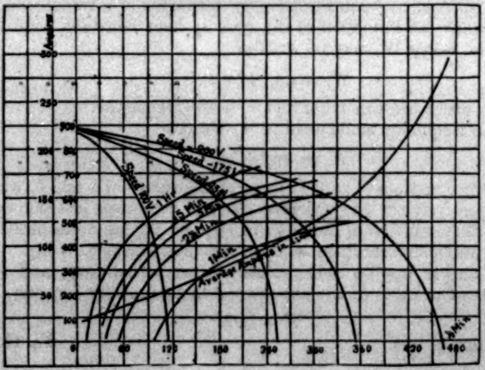
Fig. 1.—Polyphase Crane Motor, two-phase, 7,200 alts. 8-pole, 200 volts.



Pounds torque at 1 foot radius.
Rise in temperature for 8 hours' run at 20 H.P. Output, 200 volts; primary, 20° C.; secondary, 20° C.

Fig. 2.—Polyphase Crane Motor, two-phase, 7,200 alts., 8-pole, 200 volts.

Speed, torque, time, and temperature curves.



Pounds torque at 1 foot radius.

W. G. R.

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

715. *Comparative Cost of Steam-Power and Electrically Transmitted Water-Power.* **C. Saldini.** (Elettricità, Milan, 17. pp. 53–56, 1898.)—The author deals with the following costs:—(1) The annual cost of a B.H.P. produced by a steam-engine. (2) The capital cost of a B.H.P. produced by water-power, considered first at the turbine-shaft and secondly at the receiving station of an electric transmission line. (3) The annual cost of a B.H.P. in the two cases considered in (2).

Table I. gives the total annual cost of a B.H.P. produced by a steam-engine, and the various items making up the total. For engines above 500 H.P. the cost per unit is assumed constant. Coal is taken at 20 shillings a ton. Working hours per annum, 3300. Interest on capital outlay taken at 5 %. Amortisation taken at 3 % on buildings, and 5 % on machinery and boilers. Repairs not allowed for. Prices given in pounds and decimals.

The capital cost per B.H.P. of a water-power plant is from £21 to £23, and the annual cost of running from 34 to 38 shillings. Including the electrical plant, the capital cost under ordinary conditions for large powers is from £26·5 to £30 at the turbine shaft, and from £42 to £50 at the receiving station, the latter figure not including distribution expenses. For a plant of 10,000 to 12,000 H.P., assuming the lower figure, the cost is made up as follows:—

	£
Projects, Concessions, Formation of Company and General ...	3·8
Hydraulic works and Buildings	15·2
Turbines, Tubing, Gates, etc.	3·8
Alternators, Exciters, Switchboards, Crane, Reserves, etc.	7·6
Transmission-lines, Indemnities, Poles, Copper, and Accessories, Buildings of Receiving Station, Transformers, etc.	11·6
Total............................	42·0

The running expenses are calculated as follows:—

		shillings.
Amortisation on 1st of the above items	at 1·5 % ...	1·15
„ 2nd „ „	„ 1·5 „ ...	4·56
„ 3rd „ „	„ 5 „ ...	3·80
„ 4th „ „	„ 6 „ ...	9·10
„ 5th „ „	„ 3 „ ...	6·84
Maintenance and Repairs of Machinery and Line	„ 1·5 „ ...	6·84
„ „ Canal and Buildings	„ 1 „ ...	3·04
Management and Administration		7·00
Water-rights and Taxes		6·50
Sundries		9·18
		58·00
Interest at 5 % on £42		42·00
Total		100·00

This figure the author considers more as a minimum than as an average value.

On a similar basis is calculated Table II., giving the comparative cost for a year of 3300 working hours of steam-power and electric power at the receiving station. From this table it is seen that electric power has an advantage in economy only for the smaller motors, up to about 60 H.P. The author observes, however, that the working day of 9 hours can be increased in the case of electric power without appreciably increasing the annual cost per B.H.P.

[The costs given above for wages and management are based on prices holding in Italy, and should be doubled to conform to English prices. The item "Water rights and taxes" includes the Government tax of 2*s*. 8*d*. per annum per H.P. and the tax of 15 °/₀ on the profits.]

TABLE I.

H.P. of Engine.	Cost of Cardiff Coal per B.H.P.	Wages, Oil, etc.	Working Costs per B.H.P.	Interest on Capital.	Amortisation of Capital.	Total Cost per B.H.P.
1	11·3	32·3	43·6	3·8	3·8	51·2
3	10·4	13·5	23·9	1·9	2·8	28·6
8	8·5	5·7	14·2	1·7	2·1	18·0
15	7·4	3·2	10·6	1·45	1·8	13·8
25	6·5	2·3	8·8	1·35	1·7	11·8
40	5·25	1·7	6·95	1·20	1·65	9·8
60	4·50	1·35	5·85	1·15	1·50	8·5
90	4·00	1·15	5·15	0·95	1·30	7·4
150	3·55	0·95	4·50	0·85	1·20	6·5
200	3·25	0·75	4·00	1·95		6·0
250	3·00	0·70	3·70	1·90		5·6
300	2·85	0·65	3·50	1·80		5·3
400	2·65	0·60	3·25	1·70		5·0
500	2·55	0·55	3·10	1·70		4·8

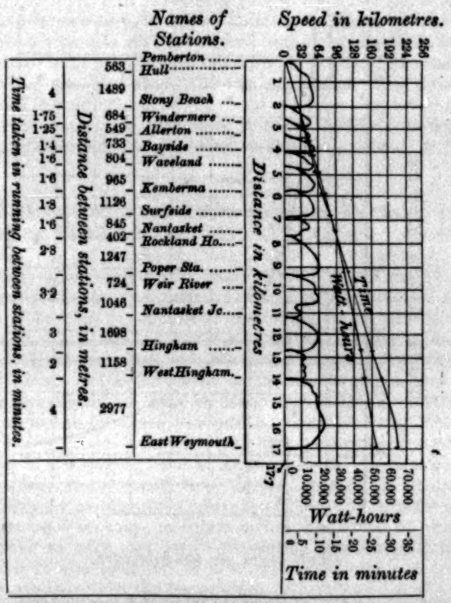
TABLE II.

H.P. of Engine.	Annual Cost per B.H.P. Steam. Pounds.	Annual Cost per B.H.P. Electricity. Pounds.	Difference. Pounds.	Cost per kilowatt-hour. Steam. Pence.	Cost per kilowatt-hour. Electricity. Pence.
1	51·2	22·8	28·4	5·07	2·26
3	28·6	17·9	10·7	2·83	1·77
8	18·0	15·2	2·8	1·78	1·51
15	13·8	13·3	0·5	1·37	1·32
25	11·8	11·4	0·4	1·17	1·13
40	9·8	9·5	0·3	0·97	0·94
60	8·5	8·4	0·1	0·84	0·83
90	7·4	7·6	−0·2	0·73	0·75
150	6·5	6·9	−0·4	0·64	0·68
200	6·0	6·4	−0·4	0·59	0·63
250	5·6	6·0	−0·4	0·56	0·60
300	5·3	5·8	−0·5	0·53	0·58
400	5·0	5·5	−0·5	0·50	0·55
500	4·8	5·3	−0·5	0·48	0·53

G. H. BA.

716. *Electric Railways.* **G. Pellissier.** (Écl. Électr. 14. pp. 273–278, 335–339, 367–370, 1898.)—The author first considers the competition between railways and tramways, and the maximum distance which is permissible between stations in order that a railway should retain its traffic when there is a competing tramway. Some account is then given of the Nantasket Beach and Hartford lines (see Abstract No. 218). The importance of high acceleration is pointed out. On the Nantasket Beach line, the distance of 17 km. (10·6 miles) is run at an average speed of 40 km. (25 miles) per hour, including the 16 stops. The speed between stations is graphically shown in Fig. 1, which is reproduced, and refers to a train 56·3 tons in weight. Between Windermere and Allerton, a distance of only 500 metres (550 yds.), the speed rose to 50 km. (31 miles) per hour. The power amounted to 52·1 watts per ton. In the case of a train of 31 tons, the maximum speed of 65 km. (40½ miles) per hour was attained at the end of 67 seconds from the start, the energy expended amounting to 90 watt-hours per ton. On the New Britain and Hartford line the ordinary trains,

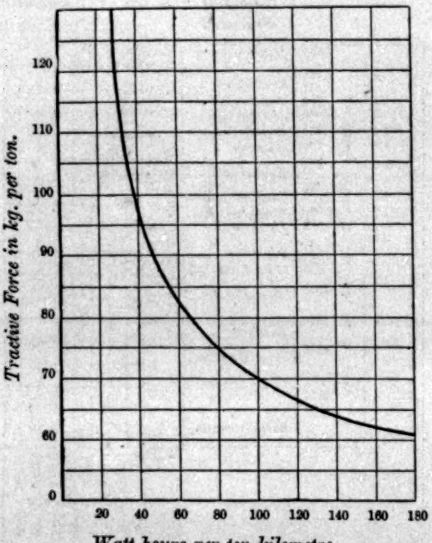
Fig. 1.



consisting of a motor car and two trailers, reach a mean speed of 45 to 50 km. (28 to 31 miles) per hour, and special trains a mean speed of 90 km. (56 miles). In the experiments made for the Illinois Central Company, a car of 25 tons carrying 18 people and equipped with four G.E. 50 H.P. motors, attained a speed of 66 km. (41 miles) per hour in 20 seconds, but the power required appears excessive. A table is given showing the tractive force, acceleration, etc. of some steam and electric railways in the United States.

In the second part of these papers the author considers the economy to be effected by the use of high acceleration. The curve in Fig. 2 gives the relation between tractive effort employed in acceleration and the expenditure of watt-hours per ton-kilometre, supposing the run between two stations to consist in uniform acceleration, drifting, and braking (see remarks by Steinmetz, Abstract No. 346). The most economical acceleration to adopt must depend upon the conditions in each particular case. The increased expense of high speed is to a large extent balanced by the decrease in rolling-stock, power, station, and staff for the same service, and by the increase of traffic which always results.

Fig. 2.



The third contribution refers to the high-speed traction scheme suggested by C. H. Davis and F. S. Williamson (see Abstract No. 340). W. R. C.

717. *Economics of Central Station Working.* **C. P. Feldmann.** (Écl. Électr. 14. pp. 427–430 & 475–477, 1898.)—In this paper the efficiencies of the various transformations of energy in transit from the coal to the lamps are discussed in detail, with the aid of diagrams, and the conclusion is arrived at that the most promising opening for improvement is in the efficiency of the lamps. Tables based on stated assumptions are given, showing the amount of coal consumed, the fixed and operating expenses, and the corresponding selling price, per kilowatt-hour, with load factors varying from 5·7 to 68·5 per cent.; the price ranges from 10*d.* per kilowatt-hour in the former case, to 1*d.* in the latter. The price of supply for electric traction is also considered, and is estimated at 1*d.* per kilowatt-hour with a load factor of 34·25 per cent. The possibility of improving the load factor by the application of electricity to heating and chemistry, and by the use of special systems of charging for electrical energy, is discussed, and the method of charging adopted at Rheinfelden is described in detail. A. H. A.

718. *Difficulties in Heavy Electric Traction.* **L. Bell.** (Elect. World, 31. pp. 23–25 & 67–68, 1898.)—The author points out that the possibility of working long railways electrically more economically than with steam locomotives depends rather upon the efficiency of line and motors than upon the reduction of the coal bill. The case is considered of working an actual line which now employs 665 steam locomotives on a road of about 1700 miles in length. Even assuming high-tension alternating current to be delivered direct to the locomotives, the result shows that there would be practically no gain in economy. With dense traffic in compact suburban districts the case is very different. One disadvantage in electric traction is the serious danger of a general breakdown of the system from a single accident. With regard to line efficiency, there would be a decided gain in all except the shortest lines by employing a pressure of 750 volts in place of the usual 500 to 600 volts. Motors could be made to work as satisfactorily as with the lower pressure. Another difficulty is experienced in the selection of a suitable conductor. A trolley-wheel is unsatisfactory for heavy work or high speed, and a third rail is troublesome at crossings. W. R. C.

719. *Central London Railway.* (Engineering, 65. pp. 214–216, p. 236, pp. 259–263, & pp. 329–331, 1898.)—On pages 214–216 is given the history of the development of Underground Railways in London, with a brief reference to the different projects for rapid transit in London. Then follows a statement of

the inception and development of the Central London Railway together with a schedule of the proposed service. A map of the route with the stations marked thereon is given.

Page 236 contains complete description of locomotive and particulars of the electrical equipment and also method of bonding track rails and description of third rail, with illustrations of locomotive, motors, controllers; third rail and curves of speed and torque of the motors.

Pages 259–263 contain description of generating station and plant. A diagram of the losses and constants pertaining to the system, comparison of the losses for a supply on the three-wire system and on the three-phase system which was finally adopted, curves for the speed over part of the route for a given average speed, and a statement of losses and efficiencies of the Power plant. The article contains illustrations of the three-phase generators, rotary converters, and transformers and H.T. switch.

Pages 329–331. This article deals with the methods of construction of the tunnel, and the nature of the work and the strata passed through, with an illustration of the machinery employed.

H. F. P.

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720. *Testing Railway Circuits.* **S. F. Jeter.** (Street Rly. Journ. 14. p. 135, 1898.)—The author proposes the use of an auxiliary test wire to be connected with the trolley wire and ground at some distant place, and connected with a voltmeter at the generating station. The other voltmeter terminal being connected successively with the line and earth, the drop of volts can be determined both along the line and through earth.

W. G. R.

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721. *Trucks for Double Deck Cars.* (Street Rly. Journ. 14. pp. 57–58, 1898.)—The use of double deck cars, as in England, increases the difficulties as to oscillation, owing to the fact that the centre of gravity is raised 30 ins., bringing it to about 7 feet above the track. No trouble would arise with a long spring base together with a 7 ft. wheel base. But in European practice a wheel base of 5 ft. 6 ins. or 6 ft. is usual, and therefore the Peckham Truck Company have resorted to the counterweight principle of balancing the weight of the car, when it tends to oscillate, by that of the motors, wheels, axles, and side-frames. This is effected by the use of springs in tension placed below the usual end-springs that are in compression. The cars at Leeds, Dublin, and elsewhere are constructed on this principle. W. R. C.

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722. *Electric Railway Feeders.* **G. T. Hanchett.** (Amer. Electn. 10. pp. 104–105, 1898.)—The author attempts to formulate working rules for the calculations concerning railway feeders. Rails are usually designated by their weight in pounds per yard. If w is this weight, then the weight in tons per mile is $0{\cdot}88\ w$.

Rails are usually supplied in 60-ft. lengths, so that there are 88 rails and 88 bonds to the mile.

The following table will assist in estimating the cost of bonding:

SIZE AND COST OF COPPER BONDS.

Weight of Rail. Pounds per yard.	Equivalent Copper Bond. Circular mils.	Cost of Equivalent Bond.
5	90,909	$0·39
10	181,800	0·59
15	272,700	0·83
20	363,600	1·04
25	454,500	1·27
30	545,400	1·51
35	636,300	1·73
40	727,200	1·97
45	818,100	2·20
50	910,000	2·43
55	1,000,000	2·65
60	1,091,000	2·88
65	1,182,000	3·12
70	1,275,000	3·36
75	1,364,000	3·59
80	1,455,000	3·82
85	1,546,000	4·05
90	1,637,000	4·28
95	1,727,000	4·54
100	1,819,000	4·78
105	1,909,000	4·92
110	2,000,000	5·19

A 55-lb. rail is electrically equivalent to one million circular mils. Therefore, if we have a rail of weight *w*, divide this by 55, and multiply the result by one million, we get the equivalent copper cable for that rail. Also a foot of rail will carry an amperage equal to one hundred thousand times its weight per yard with a drop of 55 volts. If this current is divided by the number of feet over which current is to be transmitted, we get the current the rail will carry for that distance with a drop of 55 volts. Since this is quite a usual drop of volts these rules may be applied.

W. G. R.

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723. *Train Resistance.* (Engineer, 85. p. 151, 1898.)—Tractometer experiments seem to indicate that the resistance of a train increases with the speed. On the other hand, indicator diagrams taken at high speeds invariably show a lower mean effective pressure than diagrams taken at lower speeds; thus apparently showing that the total resistance of engine, tender, and train diminishes as the speed increases.

A. S.

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724. *Engines for Electric Traction.* **C. E. Emery.** (Street Rly. Journ. 14. pp. 23–36, 1898.)—A former paper (Street Rly. Journ. Oct. 1897) treated of large cross-compound Corliss engines: the present paper deals with "intermediate speed engines," running at 100–200 revs. per min. The engines described are the "Porter-Allen," the "Buckeye," the "Brooklyn-Edison," made by McIntosh, Seymour & Co., and the "Paterson" made by the Ball & Wood Co. In the Porter-Allen engine the distribution of steam in each cylinder is effected by four independent flat-balanced slide-valves; in the "Buckeye" engine piston-valves are used; in the "Brooklyn-Edison" four gridiron valves are used on each cylinder, the travel of the valves being across the cylinder; while in the "Paterson" engines four valves of the Corliss type are used, the steam and exhaust ports being placed in the cylinder covers. The governors and valve-gears are fully described. A. S.

725. *Steam-Storage Motor Tram-Car.* (Railway World, 7. pp. 43–45, 1898.)—The car is equipped with a small engine, a hot-water boiler or reservoir, and an air-condenser. Water is heated at the central station to a temperature of 380° F., corresponding to a pressure of 200 lbs. per sq. in., and is transferred to the boiler underneath the car body. To compensate for loss of heat by radiation, a small fire-box is provided and a pan of red-hot anthracite coal is introduced when the boiler is charged. The heat from the coal is ample to maintain the pressure for the longest trip required in practice. The air-condenser consists of a pair of steel headers, the inner faces of which are connected by 3-in. tubes, the outer faces by 2-in. corrugated tubes, leaving an annular space ½ in. wide for the exhaust steam. Speeds of 12 to 30 miles an hour are reported, and runs of 20 miles with one charging. The weight complete is 28,000 lbs. A. S.

726. *Lachmann Conduit System.* **Svilokossitch.** (Électricien, 14. pp. 331–332, 1897.)—This is an illustrated description of the Lachmann System for Electric Tramways, in which the conductors are laid in conduits so constructed that they are kept perfectly dry even if the tramway is inundated. The conduits are placed at a depth of about 15 centimetres. W. G. R.

727. *Car-Wheel Grinder.* (Street Rly. Journ. 14. p. 57, 1898.)—A machine is described for grinding worn car-wheels, so as to reduce them to an efficient working condition. It is made by the Hampden Corundum Wheel Company. W. R. C.

728. *Rail Bonding.* **H. P. Brown.** (Elect. World, 31. pp. 28–30 & 65–66, 1898.)—The author gives an historical account of rail-bonding. W. R. C.

729. *Bryan Bond.* (Street Rly. Journ. 14. p. 58, 1898.)—This bond appears to be giving a good deal of satisfaction. The Consolidated Traction Company report a large saving in the return

circuit by its use, amounting in some cases to 20 per cent. The bond consists of two wires held by grooved washers. Against the rail is first placed a thin corrugated copper washer, then a grooved copper washer, and lastly a grooved steel washer, the three being held firmly in position by a bolt passing through the web and well screwed up. W. R. C.

730. *Constant-Current Acceleration Controller.* (Elect. World, 31. pp. 385–386, 1898.)—The object of this controller, due to S. H. Short, is to maintain the current in starting a car practically constant, and thus obtain uniform acceleration. There are seven notches. The first three cut out successive portions of a dead resistance; the three following short-circuit parts of the field-winding; the seventh replaces the whole field in circuit, the car having then reached its normal speed. After the first notch the action is automatic, and thus does not depend on the motor-man. This method depends upon a considerable field-commutation, and therefore ample magnetic cross-section. The motor must also be made with a greater margin of available power, in order to avoid great distortion of the field with a reduced number of field-turns; it must therefore be heavier than is required with ordinary control. A further objection to the method is that light cars will start much more rapidly than those that are heavily loaded. W. R. C.

731. *Storage Batteries in Traction-Stations.* (Street Rly. Journ. 14. pp. 1–3, 1898.)—An account is given of the advantages experienced at Pittsburgh by the use of a battery at one of the power-stations. W. R. C.

732. *Cost of Electrical Energy.* (Elect. Rev. 42. p. 239, 1898.)—Some figures are given, due to Shallcross, bearing upon the price which should be charged by electric lighting companies supplying energy to traction systems. The estimate goes to show that 1¼*d.* per unit is a profitable price in the case of a 15,000 H.P. plant working 18 hours per day at a little less than half-load, if it produced 2,000,000 units per annum. An estimate is also given in the case of working at full-load. W. R. C.

733. *Enclosed Arc Lamps.* **J. H. Hallberg.** (West. Electn. 22. p. 175, 1898.)—This paper gives the results of experience with enclosed arc-lamps, and in addition to a large amount of detailed information on the construction and working of these lamps, advocates the use of high-tension enclosed arc-lamps in cases where larger units are required. C. K. F.

734. *Vacuum-Tube Lighting.* **N. Tesla.** (Elect. Rev. N. Y. 32. pp. 8–9, 1898.)—Some photographs taken by means of a 1000 c.p. vacuum-tube are reproduced. No quantitative results are given. W. R. C.

TELEGRAPHY AND TELEPHONY.

735. *Hertz Telegraphy.* **K. Strecker.** (Electrician, 40. p. 791, 1898.)—This is an abstract of a paper read before the Elekt. Verein, 22nd February, 1898. When Morse signals are to be transmitted by means of a Hertz oscillator and a coherer, the spacing and duration of dots and dashes are not of cardinal importance. If, however, a Hughes instrument is to be employed, the succession of current-impulses must be very carefully timed. Synchronism is possible only at comparatively low speeds. The author therefore concludes that for Hertz telegraphy the Hughes instrument has no advantages over the Morse. A diagram shows the method of applying the Delany closed-circuit relay system at a receiving station between the coherer and a Morse instrument; the effect of this relay is to interpose inertia, and thus to shorten the dots and dashes. R. A.

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736. *Telephone Finance.* **J. J. Nate.** (West. Electn. 22. pp. 159–160 & p. 174, 1898.)—These two articles give a condensed account of the present financial situation of telephone-working in America. The conditions that determine the cost of maintenance are carefully discussed, the equipment of exchanges both as regards apparatus and staff is considered, and figures are given as to the rate of earning of a telephone system, making due allowance for rentals and reconstructions. Some idea is given of the progress made in toll-lines in the United States; and here the author calls attention to the serious losses incurred through lack of uniformity in the telephone apparatus. The apparatus at one exchange may be quite unsuited for efficient service over the lines or throughout the system of a neighbouring exchange; this condition is often due to the purchase of cheap and inferior material for small exchanges, which is altogether inadequate for toll-line service. A well-equipped and well-operated telephone exchange in America is generally able to show a profit of 20 per cent. *net* on the total capital. R. A.